ASSESSING REGIONAL POWER MARKET IN SOUTH ASIA GROWTH QUADRANGLE

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by
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CERTIFICATE

It is certified that the work contained in the thesis entitled, " Assessing Regional Power Market In South Asia Growth Quadrangle" by Nalin B. Dev Choudhury has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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February 2003

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Abstract

While Asia is often termed as engine for long term. growth of the world economy, it still lacks the energy resources to fuel this engine. Countries of South Asia have been facing energy shortages especially in terms of electricity. While the power sector itself improves on many fronts, till a congenial investment environment is brought forward, the people of the region may have to live with less energy to consume while endowing substantial energy resources in the region. For example, Indian power system has been facing 12.6 % peak shortage and 7.5 % energy shortage. A large proportion of population in Bhutan and Nepal still relies on non-commercial energy sources and are not connected to the grid. There exists regional disparity, in terms of energy demand and energy resources especially those for electricity. While there is substantial hydropower potential in Nepal and Bhutan, India is endowed with coal resources and there are significant natural gas reserves in Bangladesh. World over, countries have come together to commercially trade power across their borders. The American, European and African continent are home to multilateral power trade arrangements by forming power pools. In this context, setting up of a regional power interconnection to exchange electricity across the countries of the region has been advocated. This thesis assesses electricity trade potential in the South Asia Growth Quadrangle (SAGQ) region, comprising of Bangladesh, Bhutan, India and Nepal. The thesis also discusses various prerequisites for development of power market in the region. In this direction the thesis attempts to forecasts electricity demand for the four countries of the region for alternative growth paths and compare it with the projected supply scenario in 2006-07. The thesis recommends development of a regional power market to ensure better availability of electricity in the region.

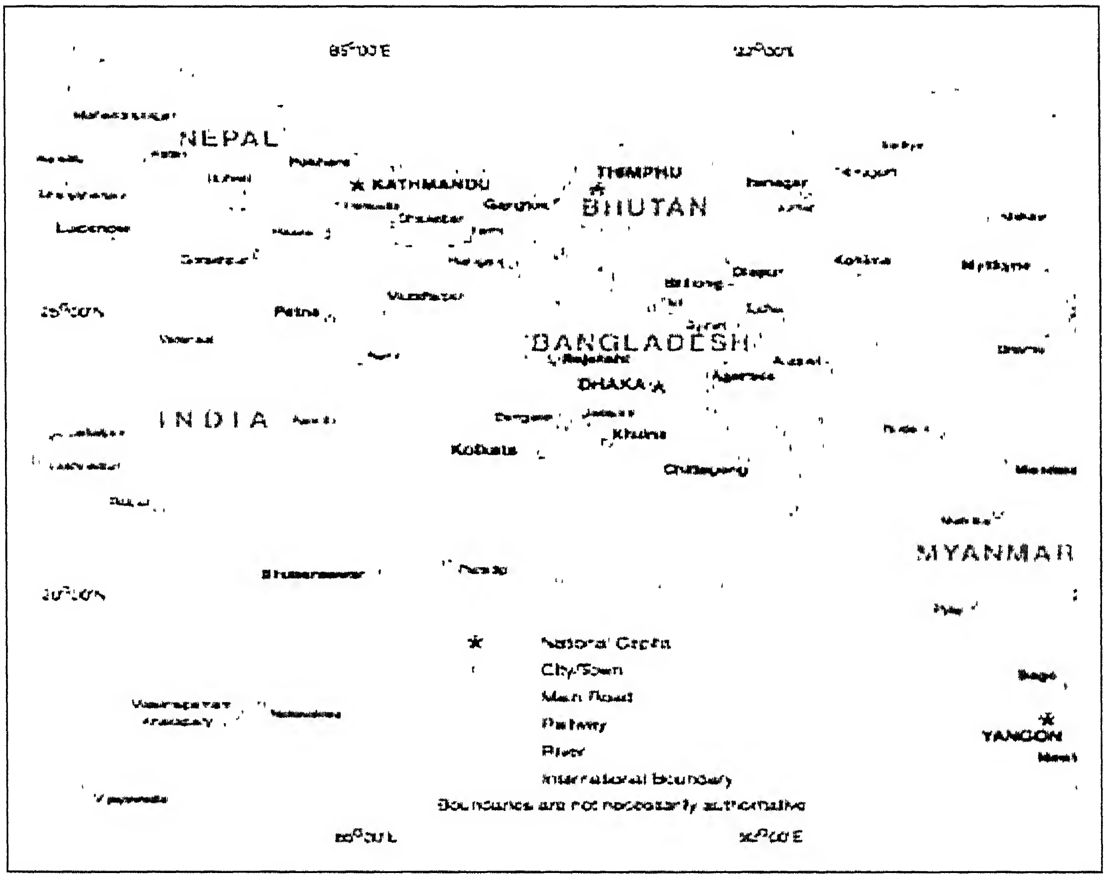
Chapter 1

Introduction and Overview

1.0 Introduction

South Asia includes India, Bhutan, Nepal, Bangladesh, Sri Lanka, Pakistan and Maldives. Figure 1.1 shows the location of these countries. Nepal and Bhutan are in the Northern and North-Eastern border and Bangladesh is in the Eastern border of main land of India. Pakistan is in the North Western border and Maldives and Sri Lanka are in the Arabian Sea and Indian Ocean respectively.

Figure 1.1: Geographic Map of South Asian Region.



Source: SASEC, 2003

The Head of the state or Government of these countries agreed to establish South Asian Association for Regional Cooperation (SAARC) on December 8, 1985. SAARC provides a platform for peoples of South Asia to

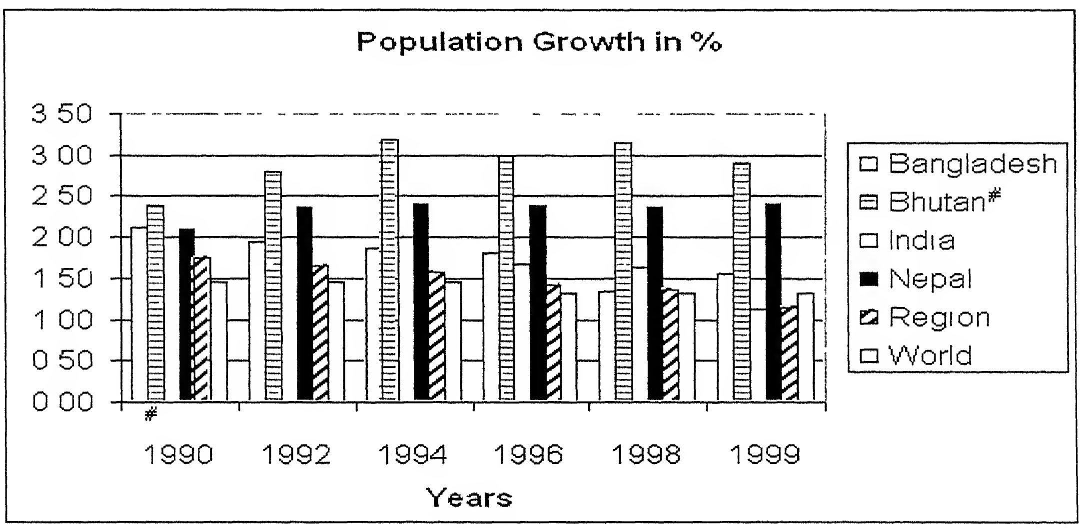
work together in a spirit of friendship, trust and understanding. It also aims to accelerate the process of economic and social development in member states. Furthermore, to speed up the economic growth of Bangladesh, Bhutan, India and Nepal, South Asia Growth Quadrangle (SAGQ) was launched by the Foreign Ministers of Bangladesh, Bhutan, India and Nepal in April 1997 and formally recognized and endorsed at the SAARC Summit in May 1997, Maldives.

The developing and underdeveloped countries of the region also face energy shortage, especially electricity as discussed later in this chapter. In order to address energy related problems of the region, development of regional energy market, especially for electricity has been advocated. In this context, this thesis attempts to assess the potential for electricity trade in the SAGQ region.

1.1 Socio Economic Scenario of the SAGQ region

Some of these South Asian countries are developing and some are under developed. Moreover, the economic growth is very slow compared to other developed countries. The major threat is that the population growth (Figure 1.2) of these countries is very high compared to other developed countries.

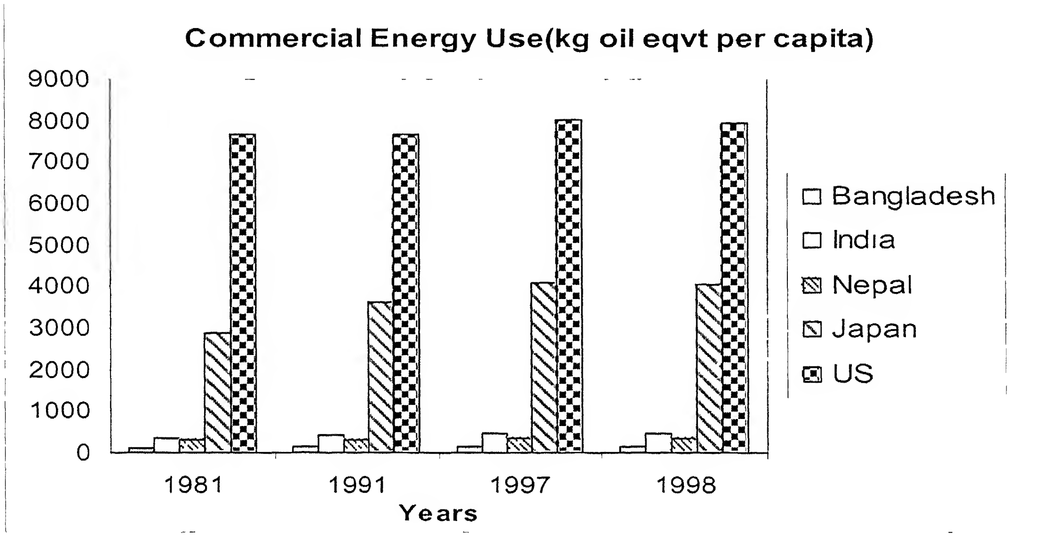
Figure 1.2: Population Growth of South Asian Region



Source: ABD, 2001.
#: WRI, 2001

Therefore, a large section of the population lies under poverty level. The per capita energy consumption (Figure 1.3) of these countries are very less compared to other developed countries like US and Japan etc.

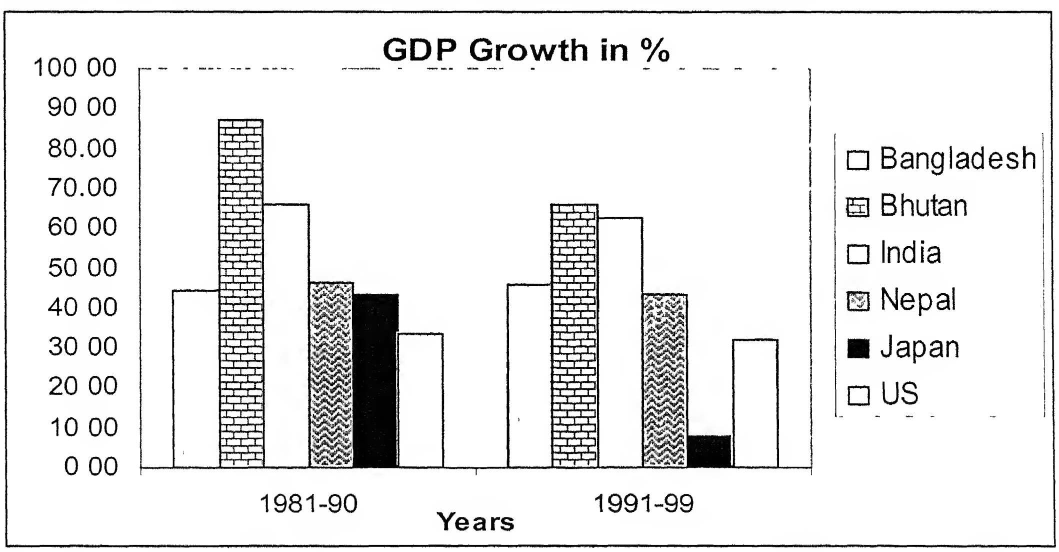
Figure 1.3: Commercial Energy Use per capita in kg oil equivalent.



Source : WDI, 2000.

More of the people lives under poverty level less is the use of energy. But the economic growth trend of these countries shows that in spite of high population growth, economic growth is higher than the developed countries. GDP growth rates in the decade of 80's and 90's is reported in figure 1.4.

Figure 1.4: GDP Growth of SA region and comparison.



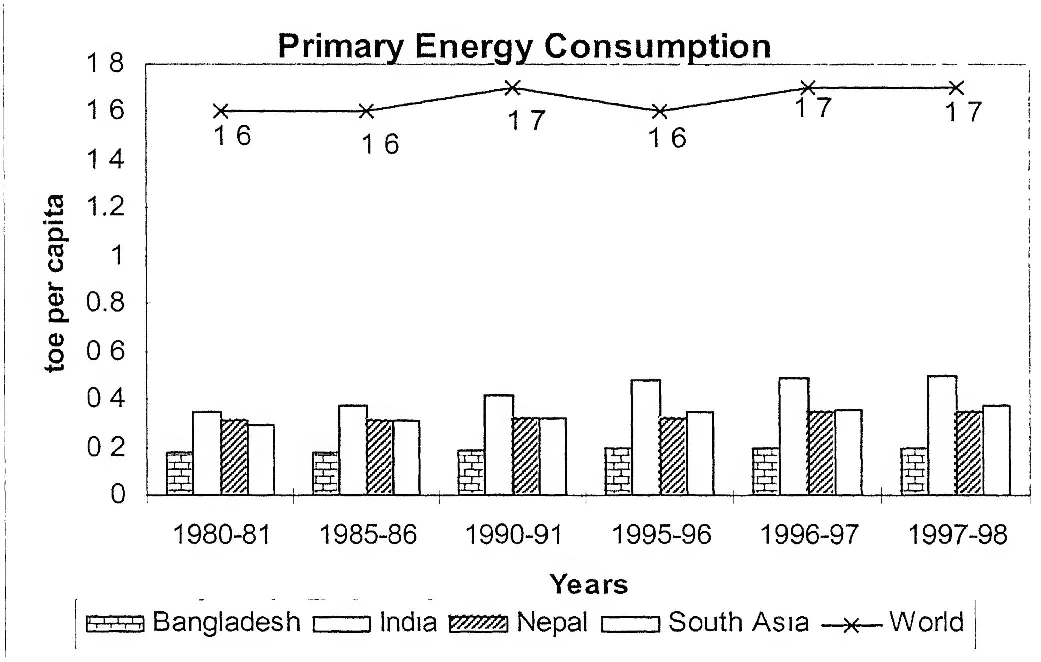
Source: WDI, 2000

The economic growth is closely tied with the energy used by the population. Energy is mostly used in domestic, industrial, agriculture, transportation and services In chapter 2 we will focus the energy availability from different sources for Bangladesh, Bhutan India and Nepal.

1.2 Energy Scenario in the SAGQ Region

The South Asian region, which comprises Bangladesh, Bhutan, India and Nepal is home to 1.2 billion people, close to a quarter of the world's population. The region is currently experiencing a rapid growth in energy demand, concomitant with economic growth and industrialization. Adequate energy supply is, therefore, a major challenge facing the economies in the region. Economic growth in South Asia averaged 5.3% a year between 1990 and 1997 with India recording the highest growth rate of 5.4% in the same period **(Kumar, 2002)**. Kumar also in his analysis reports that the total primary energy supply in South Asia, which is indicative of the total energy consumption, increased at the rate of 3.6% annually during that period. Despite the rapid growth in energy demand, the average per capita energy consumption in the region is lowest in the world. This is shown in Figure 1.5. In 1997-98, the average per capita energy consumption was 0.37 toe compared to the world average of 1.7 toe. Though the regional average has increased in the recent years, it has remained far below the world average; in Bangladesh and Nepal, it continues to remain far below even the regional average. A similar trend is observed in the case of per capita oil consumption, with a regional average of 0.08 toe compared to the world average of 0.60 toe (1997-98 figures).

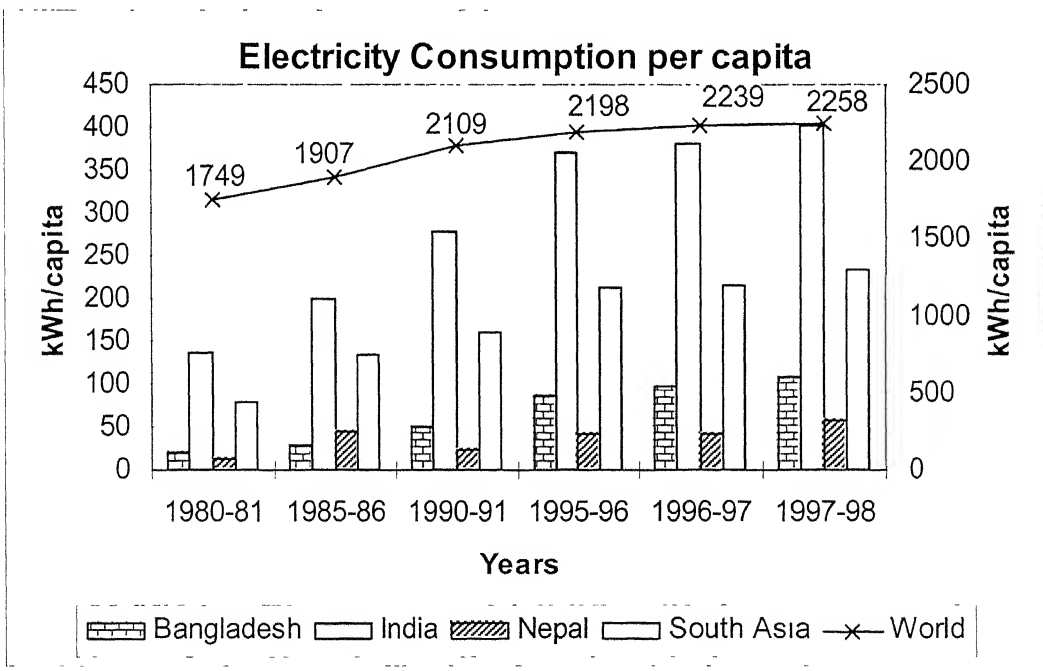
Figure 1.5 : Primary Energy Consumption in toe per capita



Source : IEA, 2001

The regional per capita electricity consumption of 219 kWh was also far below the world average of 2258 kWh in 1997-98. This is reported in figure 1.6

Figure 1.6: Electricity Consumption per capita in kWh/capita.



Source : IEA, 2001

Another point to be noted here that, self-sufficiency[1] in the region declined from 86% in 1990-91 to 81% in 1997-98, and this trend is likely to continue in the future in light of the increase in energy demand thereby necessitating larger imports. Therefore, indigenous energy supply needs to be urgently enhanced (Padmanaban and Sarkar, 2001)

IEA, (1999) reports that South Asia accounts for less than 0.5% of the world's crude oil reserves and produced 40.5 million tones in 1997-98. India's recoverable reserves of crude oil and natural gas have declined continuously after peaking at 806 million tones and 735 billion cubic meters, respectively, in 1991-92 (TERI, 1999). The current balance of recoverable reserves in India is estimated at 726 million tones of crude oil and 692 billion cubic meters of natural gas. Most of the crude oil production in South Asia is accounted for by India, which, in 1997-98, accounted for 93% (38 million tones) of the total oil production in the region.

1.3 Resources and Location Constraints

These four South Asian countries are having resource constraints and resource mismatch/disparity. Infrastructural constraints including energy shortage are dragging the growth of the countries of the region. Distribution of energy resources is not uniform in the region. While India and Bangladesh have fossil fuel reserves, Nepal and Bhutan have good potential to harness hydro power. This has necessitated energy trade among countries of the region, though on a bilateral basis.

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[1] self-sufficiency in energy, which is expressed as energy production as a percentage of the total primary energy supply

Bangladesh is having proven oil and natural gas reservoirs. It has 59.6 Million Barrels of oil reserve and 32.1 Trillion Cubic feet gas reservoirs. Bangladesh has 4680 MW of installed capacity of electricity generation by September, 2002 (BPDB, 2002). Electricity production as on 2000-01 was 14828.18 GWh, 82.88% from natural gas, 6% from oil and 5.44% from hydro generation (BPDB, 2002). Less than 28 percent of population had access to electricity in the 2000. The mismatch of resources is there in Bangladesh also. Eastern zone of Bangladesh has large resources of natural gas but the consumption rate in the Eastern zone is very less and the utilization of gas for industrial development is poor. Most of the Industry lies in the Western part of Bangladesh. This is a disparity of resources. Again Western part of Bangladesh is connected to West Bengal of India. It may be a viable project to import gas from Bangladesh through Western side.

Bhutan doesn't have oil and natural gas reservoir and have to import from other countries. Here comes the economic viability and other constraints. Bhutan is located on the foot hills of greater Himalaya range. Bhutan shares its Northern border with China (Tibet) and Southern and Western border with India. Therefore for Bhutan it is natural constraint to trade with other countries other than India particularly in energy sector. Most of the requirement of fuel, gas and petroleum is met by the Indian export. But on the other hand, Bhutan is having vast hydro electric resources of 20000 MW. Currently Bhutan has power generation capacity of 3530 MW (Bhutan, 2001).

Nepal is also situated on the foot hills of greater Himalayan range. It shares its Southern border with India and Northern border with Peoples Republic of China. Nepal has also the natural constraints for import and

export without using Indian Land. Therefore, most of the import and export of energy is through India. Nepal is having tremendous potential for hydro electric generation. Nepal is also not having proven oil and gas reserves or oil refining capacity. All the oil and gas is imported from India only. Nepal has 2 Million tones of coal reserves. Coal production on 2000 was 10000 tones and imports 356,000 tones with total consumption 366000 tones. Similarly, Nepal has power generation capacity of 0.262 Million kW (83% is from hydro electric of total power) and 0.054 Million kW (17% from thermal of total power). Currently, according to 2000 data, electricity generation is 1.125 Billion kWh from hydro and 0.12 Billion kWh from thermal with a total of 1.245 Billion kWh.

1.4 Current Energy and Peak Demand Scenario

In 2001, total electricity generation in Bangladesh was 16254 GWh, where from hydro source it was 1138 GWh (5.71 percent), Gas 14141 GWh (87.56 percent) and from petroleum fuel 975 GWh (6.74 percent). In 2001, installed capacity was 4230 MW. In 2001, the actual consumption according to official data should be 17719 GWh **(Bangladesh, 2002)**. The deficit was approximately 1464 GWh (7.6 percent). In 2001, Bangladesh had the peak demand 3109 MW. This peak demand was met completely by the installed capacity. But the interesting point to be noted herewith that in 2002, Bangladesh had an installed capacity of 4680 MW with an attainable capacity of 4055 MW but the peak demand was 3459 MW. Bangladesh has the overall system load factor of 60 percent and system loss (overall) 30 percent with a population access to electricity. This means Bangladesh can meet its peak demand well but can not meet its energy requirement.

During the Eight Five Year Plan of Royal Government of Bhutan (1997-2002), 82.4 MW of installed capacity and 506 GWh of energy is added to its existing capacity and increased from 361.6 MW to 444 MW and from 1838 GWh to 2344 GWh. But the internal consumption in Bhutan in 2000 was only 532 GWh and this consumption increases in 2002 to with a growth of 9.53 percent **(Bhutan, 2001)** was approximately 638 GWh. Bhutan is having approximately 72.77 percent of surplus electricity. This excess electricity is exported to India.

Nepal also has a similar situation. In 2000-01, total available energy in Nepal was recorded to be 1868.42 GWh, it is 9.81% higher from the previous financial year. The peak load recorded was 391.0 MW. The electricity generated from the hydro sources was 1614.74 GWh (86.42 percent), thermal 27.14 GWh (1.45 percent), Import from India 226.54 GWh (12.12 percent). Nepal also export electricity to India through isolated line in different voltage levels in off peak hours **(NEA, 2001)**

As on 31.3.2001, all India Installed capacity of electric power generating stations was 101630.08 MW, consisting of 25141.78 MW hydro, 72358.67 MW thermal, 2860 MW nuclear and 1269.63 MW wind which has increased to 103134.06 MW as on 31.12.2001 consisting of 25574.03 MW hydro, 73273.97 MW thermal, 2860 MW nuclear and 1426.06 MW wind. In 2000-01, India had the requirement of 507216 GWh, where availability was 467400 GWh with a shortage of 39816 GWh (7.8 percent). Again in 2000-01, India had the peak demand of 78037 MW where 67880 MW was met with a shortage of 10157 MW (13 percent)**(India, 2002a)**. The current trading of electricity with Bhutan and Nepal is discussed in next section.

1.5 Present Status of Energy trade

India has its energy trading with all the neighboring countries including Bangladesh, Bhutan and Nepal. This trade is governed by the treaty signed with those countries.

Bangladesh also signed Trade Treaty[2] with India and in Article 6 it is clearly written that "The high Contracting Parties further agree to make joint studies and take point action in the fields of flood control, river basin development and the development of hydro-electric power and irrigation." Again from Government of India official data it is revealed that up to 1997-98 Bangladesh had imported coal from India[3]. Furthermore, it is also stated that there is no trade on Electricity and gas with India[4]. The talks on trading of electricity between India and Bangladesh is still going on and the process was started in last May, 1997[5]. The exact amount of coal imported from India to its neighboring countries is reported in table 1.1.

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2 "Treaty of Peace and Friendship Between the Government of India and the Government of the People's Republic of Bangladesh, Dacca, 19 March 1972"

3 Unstarred Question No 1493, To Be Answered On 28 11 2000, Lok Sabha, by The Minister of State for Coal, N T Shanmugam, Import Export of Coal by Coal India Limited and its Subsidiaries, Ministry of Coal, Government of India

4 Unstarred Question No 2046, To Be Answered On 31 03 1997, Rajya Sabha, by Dr S Venugopalachari, Minister of State in The Ministry of Power, Government Of India

5 Rajya Sabha, Unstarred question 1356, to be answered on 04 08 1997 by Yoginder K Alagh, Minster of State of the Ministry of Science and Technology and Minister of State of Ministry of Power, GOI A tripartite meeting between Government of India, Government of Bangladesh and Asian Development Bank (ADB) was held at Manila in May, 1997 to discuss the technical, financial and commercial issued including identification of potential links for transfer of power between Bangladesh and India The Asian Development Bank, under its Regional Technical Assistance Programme has agreed to finance a feasibility study for electricity exchange between India and Bangladesh The feasibility study would identify the inter-tie points, nature of power supply (i e base load, peak

Table 1.1: Export of coal from India In tonnes

Year	Bangladesh	Nepal	Bhutan
1997-98	5.86	39.59	10.51
1998-99	NIL	30.00	14.06
1999-2000	NIL	55.95	9.51
2000-2001	60.44(in crore Rs)	35.55	7.17

Source · Lok Sabha, Unstarred Question No 2221, To be answered On 03 12.2001, Shri Ravi Shanker Prasad, The Minister of State for Coal & Mines, GOI.

According to Indo-Bhutan Friendship Treaty of 1949[6] in Article V and VI it is clearly stated that there will be free trade and commerce between the territories of the Government of India and the Government of Bhutan. Moreover, this treaty also declares that Government of India grant every facility to Government of Bhutan for the carriage by land, water. Again in Article II of Indo-Bhutan Treaty, 1972[7], there was an agreement with each other identifying the areas of cooperation and complementarily in industrial and commercial plans. In 1997, at the start of the Eighth Plan, Bhutan exported 1,354 million units of electricity to India and imported 32 million units of electricity **(Bhutan, 2001)**. By 2000, export has shot up to 1,495 GWh. Taxes and dividends from hydropower sector contributed about 45 percent government revenue. Bhutan exports all its excess electricity to India only. Government of Bhutan also buys power from West Bengal and

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load or off-peak power) commercial arrangements based on international commercial practices for sale/purchase of power between countries The project envisages export of surplus power from Eastern region of India to Western Bangladesh The project also envisages export of surplus power from Eastern Bangladesh to the North Eastern region of India Initially, this would be of benefit to States belonging to the Eastern and North Eastern regions of India.

6 "Treaty of Perpetual Peace and Friendship Between the Government of India and the Government of Bhutan, Darjeeling, 8 August 1949", Source Ministry of External Affairs, Government of India, New Delhi

7 "Indo- Bhutan Trade Treaty, 1972, Agreementl Between the Government of India and the Royal Government of Bhutan Regarding Trade and Commerce", Thimphu, 17 January 1972 Source Ministry of External Affairs, Government of India, New Delhi

Assam State Electricity Boards. Already India and Bhutan has the Electrical power transmission line of 220kV. Bhutan has a very low coal production of 56000 tones and imports 28000 tones from India and exports only 4000 tones to the North eastern states of India from its eastern coal fields. Moreover, according to the government official data from Bhutan[8], it has the capacity to generate electricity from thermal using coal of 0.011Million kWh.

Royal Government of Nepal and Government of India had signed a Treaty on Trade and Commerce on 31st July, 1950[9]. According to article 2, 3 and 4 Nepal has the exemption of excise and import duties and right of commercial transit of goods. Nepal has also the natural constraints for import and export without using Indian Land. Therefore, most of the import and export of energy in particular is through India. Nepal is having tremendous potential for hydro electric generation. Nepal is also not having proven oil and gas reservoir as well as oil and gas production. All the oil and gas is imported from India only. Nepal has 2 Million tones of coal reserves. Coal production on 2000 was 10000 tones and imports 356,000 tones with total consumption 366000 tones. Similarly, Nepal has power generation capacity of 0.262 Million kW (83% is from hydro electric of total power) and 0.054 Million kW (17% from thermal of total power). Currently, according to 2000 data, electricity generation is 1.125 Billion kWh from hydro and 0.12 Billion kWh from thermal with a total of 1.245 Billion kWh (NEA, 2001a). Nepal and India also having power trading [10].

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8 Chapter 22 Energy, 9th Five Year Plan Document, Planning Commission, Royal Government of Bhutan

9 "Treaty of Trade and Commerce Between the Governments of India and Royal Government of Nepal Kathmandu, 31 July, 1950"

10 Rajya Sabha, Unstarred question 550, to be answered on 28 07 1997 by Yoginder K Alagh, Minster of State of the Ministry of Science and Technology and Minister of State of Ministry of Power, GOI India and Nepal had signed a Treaty on the Mahakali river on 29th January, 1996 The Instruments of Ratification of the Treaty was

Table 1.2: Power Import and Export with India

Country	Export	Import
Bhutan	1564 04 GWh in 2000	NIL
Nepal	120 MW Mahakali HE	210.29MW in 1998
Bangladesh	NIL	NIL

Source. Rajya Sabha, Unstarred question No 2418, To be answered on 17.03.1999 on Purchase of Power from neighboring countries, by Shri P.R. Kumaramangalam, The Minister of Power Parliamentary Affairs and Non-Conventional Energy Sources, Government of India

1.6 Objective and Scope of the Study

In order to meet the growing demand for energy especially electricity for development of the countries of SAGQ region, there is a need to develop available resources in the region and evolve a regime for energy trade in the region. In this context, this thesis attempts to assess the potential for electricity trade in the region. This could be achieved by projecting the future demand for electricity for all the four countries in the region and comparing it with the projected capacity additions. The main objectives of the thesis are –

- Econometrically estimate demand for electricity demand model for Bangladesh, Bhutan, India and Nepal.
- Forecast demand for electricity for each of the four countries.
- Make an assessment of mismatch of demand and supply situation in the four countries.
- Assess the excess and shortage of electrical energy in each of the four countries during 2006-07.

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exchanged during the Prime Minister,s visit to Nepal in June 1997 The Mahakali Treaty has come into force from 6 6 1997 A power exchange agreement was executed by the Secretary (Power) on behalf of Government of India in Feb , 1996 The Mahakali Treaty envisages construction of the Pancheshwar Multipurpose Project on the river Mahakali which will be a source of surplus power The Pancheshwar Multipurpose Project envisages construction of a storage dam Two underground power houses on either bank of the river The project would be implemented in a phased manner and has a potential of about 3000 MW A regulating structure would be required for exploiting the full power potential

- Suggest a regime for development of power market among the countries of SAGQ.

1.7 Outline of the Thesis

Chapter 2 will overview the electricity sector scenario of the SAGQ countries. The energy and the economic development of these four countries are discussed in the Chapter 3.

Chapter 4 will suggest an econometric demand model to estimate the future electricity demand of these countries. The forecasted demand and the supply and demand mismatch also covers in this chapter.

Chapter 5 covers the current situation of electricity trading among SAGQ and example of the electricity trading among countries. This chapter also explains the benefits and condition and limitations of the electricity trading.

Chapter 2

Energy Sector Scenario

2.0 Introduction

Energy Sector scenario in the developing countries of South Asia is far from configurable. The region is not well developed in terms of oil resources as compared to neighboring middle east region. However, coal and hydro power resources lend promise to meet energy demand of the region with certain caveats. This chapter overviews the existing demand and supply pattern and resources, especially the electrical energy of these four South Asian countries namely Bangladesh, Bhutan, India and Nepal. The economy of these countries is predominantly agriculture based. Agriculture amounts for 25-40 percent of the GDP in these countries.

Table 2.1 Sectoral Share of GDP in percent in 2000

Sectoral Share of GDP (%)	Bangladesh	Bhutan	India	Nepal
Agricultural Share	24.6	33.2	25.3	39.8
Industrial Share	24.4	37.3	26.2	22.1
Services	51.0	29.5	48.5	38.1

Source : ADB, 2001a.

The most significant feature of the energy consumption of these four countries is their dependence on non-commercial or traditional forms of energy like fuel wood, cow dung, agricultural wastes and other biomass. Most of this non-commercial energy is used in the household sector and is not transacted through the market.

Table 2.2 Percentage share of Commercial & Non-commercial energy in 1997

Type of energy	Bangladesh	Bhutan@	India	Nepal	South Asia	OECD	World
Commercial	54.0	23	20.7	10.4	79.7	96.7	91.8
Non-commercial	46.0	77	79.3	89.6	20.3	3.3	8.2

Source : UNDP, 2002

@ For 1989 data

The next section overviews present scenario of energy demand and supply for each of the four countries. The data are collected and presented in a cohesive manner to establish a relationship between the demand and supply with the available resources.

2.1 Present Energy Demand and Supply

2.1.1 Bangladesh

2.1.1.1 Economic Overview

The main economic backbone of Bangladesh is the agriculture. Bangladesh's real GDP grew at an estimated 5.3% rate in 2001, roughly unchanged from 5.9% growth in 2000. More than half the GDP is generated through the service sector, nearly two third of Bangladeshis are employed in the agricultural sector. Major impediments to growth includs delays in exploring energy resources like natural gas and insufficient power supplies (SDNP, 2002). The growth rate of electricity demand is high across all sectors of the economy. Economic indicators of the Bangladesh economy is shown in table 2.3.

Table 2.3: Economic Overviews of Bangladesh

Economic Indicators	Values
GDP in Current Market Price in Billion Taka(2001)	2532.5
GDP – Real growth rate (2001)	5.3%
GDP Composition by sector (2001)	
Agriculture	24.1%
Industry	25.9%
Services	50.0%
Average Annual growth of share of GDP (2001)	
Agriculture	3.1%
Industry	7.2%
Services	5.5%

Source: World bank, 2002.

2.1.1.2 Energy Sector Overview

Bangladesh has small reserves of oil and coal, but potentially very large natural gas resources. Gas accounts for 69 percent of commercial energy consumption. The remainder being met almost entirely oil with limited amounts of hydropower and coal. According to Bangladesh Power Development Board (BPDB), only around 18% of the population (25% in urban areas and 10% in rural areas) has access to electricity, and per capita commercial energy consumption is among the lowest in the world. Noncommercial energy sources, such as wood, animal wastes, and crop residues, are estimated to account for over half of the country's energy consumption. Energy overview of Bangladesh is highlighted in Table 2.4.

Table 2.4: Energy Sector Overview of Bangladesh.

Proven Oil Reserve (as on 1st Jan, 2001)	56.9 Million Barrels
Natural Gas Reserves (2000)*	32.1 Tcf
Coal reserves (1998)	None
Electricity Production (1999)	12.1 BkWh

Source : IEA, 2001

Tcf : Trillion Cubic Feet, BkWh : Billion kWh

* US Geological Survey Estimates.

Bangladesh's Ministry of Energy and Mineral Resources (MEMR) has overall responsibility for the country's energy sector, with policy formulation and investment decisions under its control. Within MEMR, the Power Cell acts as a single point of contact to facilitate the electricity reform and restructuring process and development of Independent Power Projects (IPP).

Table 2.5: Energy Scenario for different years in Bangladesh

Item	1984	1985	1990	1995	2000
ENERGY annual values					
Crude petroleum, '000 m.t.					
Production	20	22	19	10	72
Consumption	1061	1028	1166	1397	3525
Coal, '000 m t.					
Consumption	62	98	563	67	53
Natural gas, terajoules					
Production	90816	103396	183496	270419	361742
Consumption	90816	103396	173885	255559	320944
Electricity, Mn kWh					
Production	4292	4592	7135	10166	14739
Consumption	4292	4592	5294	8371	12461

Sources: ADB, 2001a.

2.1.1.3 Oil and Natural Gas

Bangladesh contains small proven oil reserves of 56.9 million barrels and produces around 1,600 barrels per day, of which 1,400 barrels per day is crude oil. In year 2000, Bangladesh produce 1600 barrels per day and net import was 58400 barrels per day with a consumption of 60000 per day (IEA, 2001). Petrobangla with its eight Operating Companies (OC) is the sole player in the oil and gas field in the country. At present some foreign companies like Shell, Texaco, Scotland's Cairn Energy PLC, Holland Sea Search, Unocal, Rexwood-Okland, and UMC Bangladesh Corporation are active in exploration under six Production Sharing Contracts (PSCs) partnership with Petrobangla. Petrobangla regulates the activities of foreign companies under PSCs, and serves as the sole purchaser of oil and gas from the companies.

Bangladesh has one refinery, a 33,000 barrels per day unit at Chittagong. TotalFinaElf (A French Company) also proposed to setup a $16-million plant to bottle liquefied petroleum gas (LPG), in a joint venture with

Bangladesh's Premier LP Gas Ltd. LPG is used in Bangladesh mainly for domestic cooking, as well as in some industries and vehicles.

Natural gas is Bangladesh's only significant source of commercial energy. In 2000, production of natural gas was 361742 terajoules. Bangladeshi gas production began in 1960 from the Chattak Field. According to a study conducted by the US Geological Survey (USGS), Bangladesh currently has estimated proved natural gas reserves of around 32.1 trillion cubic feet (Tcf) in approximately 20 gas fields (mainly onshore). Bangladesh also uses its gas resources to produce electricity, petrochemicals, and fertilizers. Petrobangla has approximately 20 gas fields nationwide, half of which are active. Major foreign energy companies active in gas exploration and development in Bangladesh include Shell, and Unocal, which operates in Bangladesh through its wholly owned subsidiary, Unocal Bangladesh Limited. Some other foreign companies like Occidental, Tullow Oil PLC, Chevron and Cairn are also active in exploration and development of gas fields. Besides foreign energy companies, natural gas in Bangladesh is being produced by two subsidiaries of state energy company Petrobangla -- Sylhet Gas Fields Ltd. and Bangladesh Gas Fields Co. Ltd. These two companies produce gas for domestic consumption. More than 80% of gas is consumed for power and fertilizer production, and the remainder by industry and households.

2.1.1.4 Electricity Sector Overview

Bangladesh's installed electric generating capacity in 1997 was 3.3 gigawatts (GW), of which around 93% was thermal (mainly natural-gas-fired), and the remainder hydroelectric, at 18 power stations. Only around 2.4 GW of Bangladesh's total electric generating capacity is considered to be available. BPDB reports the problems in the Bangladesh electric power

sector to be high system losses (up to 40%), delays in completion of new plants, low plant efficiencies, gas availability problems, erratic power supply, electricity theft and blackouts, shortages of funds for needed maintenance at the country's 18 power plants and other power infrastructure, and unwillingness of customers to pay bills. Overall, the country's generation plants have been chronically unable to meet system demand over the past decade. With only around 18% of the population connected to the electricity grid, and with power demand growing rapidly (10% annually from 1974-1994; 7% annually from 1995-1997 (EIA, 2002)), Bangladesh's Power System Master Plan (PSMP) projects a required doubling of electric generating capacity from 2002 (3659 MW) by 2010 (6779 MW). PSMP also suggests that Bangladesh may need to replace 30%-40% of current generating capacity by 2006-07.

2.1.2 Bhutan

2.1.2.1 Economic Overview

Bhutan is an under-developed country headed by a monarchy. The economy of Bhutan is based on agriculture and forestry, which provide the main livelihood for more than 90% of the population. Agriculture consists largely of subsistence farming and animal husbandry. Rugged mountains dominate the terrain and make the building of roads and other infrastructure difficult and expensive. The economy is closely aligned with India's economy through strong trade and monetary links. The industrial sector is technologically backward, with most production of the cottage industry type. During 1999, the real Gross Domestic Product (GDP) increased by 5.9% and the nominal GDP by 14.3% respectively over 1998. Again in 2000 and 2001 there is no net change in GDP growth (World bank, 2002). The good economic performance during 2000 was fueled by the

high growth in Construction, Transport, Government and electricity sectors. The high rate of growth in the construction sector was due to the large construction activities undertaken by Tala Hydro-Power Project and other hydro-power project in the country. Bhutan's hydropower potential and its attraction for tourists are key resources. Economic overview of Bhutan is shown in Table 2.6.

Table 2.6: Economic Overview of Bhutan.

GDP in Current Market Price in Million Nu. (2000)	21126.5
GDP Real growth rate (2001)	7.0%
Average Annual Growth of Share of GDP (2000)	
Agriculture	2.5%
Industry	10.3%
Service	6.6%

Source: World bank, 2002

2.1.2.2 Energy Sector Overview

Bhutan has no significant reserves of oil, natural gas, or coal. Around 98% of energy consumption in Bhutan is made up of biomass - mainly firewood. Firewood consumption data has been compiled on the basis of household energy survey carried out by the Department of Power, Bhutan. As a percentage of the total consumption of firewood, the household sector used 95%, Government and commercial establishment 3%, agriculture sector 0.9% and industry used only 0.7%. Commercial energy consumption consists of small amounts of oil products, imported coal, and hydroelectricity. Energy sector data are shown in Table 2.7.

Table 2.7 (a): Energy Sector Overview of Bhutan.

Proven Oil Reserve (as on 1st Jan, 2001)	None
Natural Gas Reserves	None
Coal reserves (1998)	1.3 million Tons
Electricity Production (1999)	1.856 billion kWh

Source : IEA, 2001

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Coal reserves (1998)	1.3 million Tons
Electricity Production (1999)	1.856 billion kWh

Source : IEA, 2001

Table 2.7 (b): Energy Sector Overview of Bhutan.

Oil Consumption (1999)	1000 Barrels per day
Net oil import (1999)	1000 Barrels per day
Coal Production (1999)	1000 tones
Coal Consumption (1999)	24000 tones
Net coal Imports	24000 tones
Electricity consumption (1999)	191.1 million kWh
Electricity Export (1999)	1.55 billion kWh
Electricity Import (1999)	15 million kWh

Source : IEA, 2001

Bhutan's household sector accounts for around three-quarters of total energy consumption. Bhutan has potentially huge hydropower resources, a result of the country's steep mountains, deep gorges, and fast-flowing rivers. The development of Bhutan's energy sector is of crucial importance to the country. In the past, the major source of energy was fuel-wood which, together with kerosene and LPG, is still widely used for domestic purposes, followed by diesel and petrol, predominantly for transport. Now, hydroelectric power is assuming a lead role in the consumption pattern of energy.

Bhutan has a minor coal reserve in the Eastern side but due to transportation problem and open cast mining, most of the excavated coal is exported to North-Eastern India. One very significant characteristics of energy consumption in Bhutan is that the agriculture sector is not dependent on energy.

2.1.2.3 Electricity Sector Overview

The theoretical potential for power generation has been estimated at 30000 MW although the exploitable capacity in Bhutan has been estimated at 6000 MW (Bhutan, 2002). There are at present 21 run off river hydro-electricity generating stations, which have a capacity to generate a total of

444 MW less than 7.4% of the estimated exploitable capacity. Existing hydro power generating capacity includes the Chukha Hydro Power Scheme with an installed capacity of 336 MW, 7 small size hydro power generating station ranging from 300 to 1500 kW and 12 micro hydels with capacity ranging from 10 to 88 MW. 97 percent of current electricity generation of Bhutan is hydro electric and the rest are thermal. Only a small percentage of Bhutan's potential hydroelectric power capacity currently is being exploited. Potentially, Bhutan could be a large net power producer and exporter to neighboring countries like India. Bhutan has plans to commission a 1,020-MW hydropower plant at Tala in 2003. With regard to harnessing of the vast hydropower potential, feasibility studies were completed for Mangdechhu Hydroelectric Power Plant (360 MW) and Punatsangchhu Hydroelectric Power Plant (870 MW). These two plants are techno-economically feasible and they will be undertaken in the Ninth Plan In addition, four feasible micro-hydel sites have been identified at Sengor, Sakten, Tang and Gasa. Construction on transmission lines for the project began in early October 2000. The two, 400-kV, double-circuit lines will enable Bhutan to export surplus power (around 90% of Tala's generation) to India. At present, Bhutan faces frequent power outages and shortages, while only around 15%-20% of the country's population has access to electricity. Rural electrification is a main priority for Bhutan. In November 1999, the Asian Development Bank (ADB) approved a $10-million concessional loan for a Sustainable Rural Electrification Project in Bhutan. In February 1999, the Japanese Electric Power Development Corporation won a contract to provide technical consulting services for hydropower development in Bhutan.

Table 2.8: Energy Scenario for different years in Bhutan

Electricity(Annual) Mn kWh	1985	1990	1995	1999	2000
Production	21	1564	1717	1746	2131
Consumption	30	172	246	391	434

Sources: ADB, 2001(a).

The energy scenario of Bhutan is shown in table 2.8. In 1985 the Electricity production was very small. After 1990 the generation of electricity increases due to addition of more hydroelectric plants. In 2000, Kurichu Hydroelectric Project also started generation.

2.1.3 India

2.1.3.1 Economic Overview

India is a developing country with agriculture and industrial based economy with a multitude of support services and its average gross domestic product growth was 5.7 percent from 1981 to 1991 and 5.9 percent from 1991 to 2001. Industrial and agricultural GDP growth during 1992-97 (Eighth five year plan) was 4.69 percent and 7.58 percent respectively and the same during Ninth five year plan (1997-2002) was 2.06 and 4.51 percent. Another point to be noted that the rate of growth has declined particularly in the agriculture and industrial sectors, as compared to the Eighth Plan, whereas in the services sector there has been marginal increase in the growth rate from 7.54 to 7.78 percent. Share of agricultural GDP decreased from 44 percent in 1973-74 to 26.9 percent in 1999-2000.

Table 2.9: Economic Overview of India

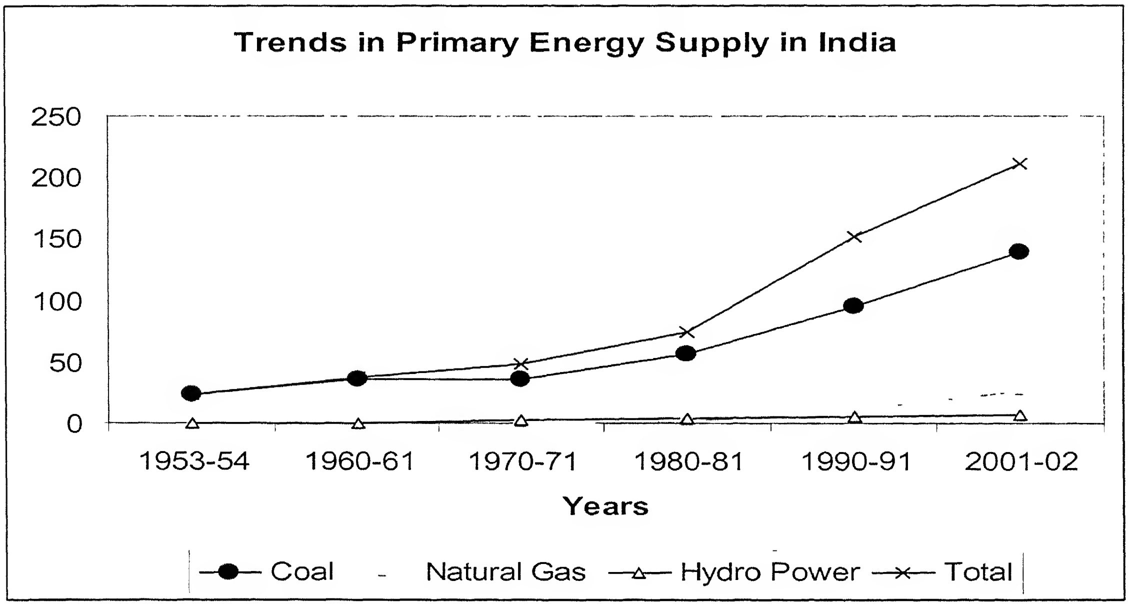
GDP in Current Factor Cost in LCU (2001)	20802.5 Bn. Rs.
GDP Real growth rate (2001)	4.0%
GDP composition by sector (2001)	
Agriculture	24.9%
Industry	26.9%
Service	48.2%
Average Annual growth of share of GDP (2001)	
Agriculture	1.3%
Industry	4.9%
Services	9.5%

Source : World Bank, 2002

2.1.3.2 Energy Sector Overview

India ranks sixth in the world in terms of energy demand accounting for 3.5 percent of world commercial energy demand in 2001 (India, 2002). Although, commercial energy consumption has grown rapidly over the last two decades, a large part of India's population does not have access to it. At 479 kg of oil equivalent (kgoe), the per capita energy consumption is also low even compared to some of the developing countries (refer figure 1.3). As per current projections, India's dependence on oil imports is expected to increase (India, 2002b). The demand of natural gas also outpaces supply and efforts are being made to import natural gas in the form of liquefied natural gas (LNG) and piped gas. The power sector has also been experiencing severe shortages. This shortage of electricity will be discussed in the subsequent chapter.

Figure 2.1 : Trends in Primary Energy Supply in India.



Source : India, 2002(b)

Primary commercial energy demand grew almost three-fold at an annual rate of 6 per cent between 1981 and 2001, to reach 314.7 million tones of oil equivalent (mtoe).

Table 2.10: Energy Sector Overviews of India

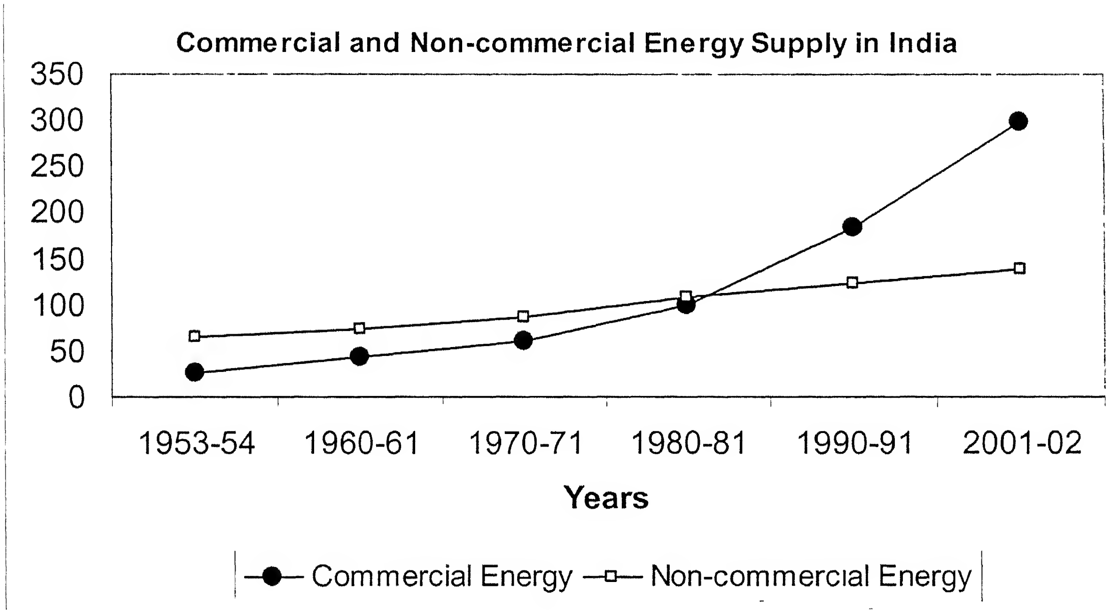
Energy Scenario	
Electricity Production (1999)	454.561 BkWh
Electricity Production by Source in Percent (1999)	
Fossil Fuel	79.41%
Hydro Electric	17.77%
Nuclear	2.52%
Others	0.3%
Electricity Consumption (1999)	424.032 BkWh
Electricity Export (1999)	200 MkWh
Electricity Import (1999)	1.49 BkWh

Source : IEA, 2001.

Planning Commission reported that India's incremental energy demand for the next decade is projected to be among the highest in the world, spurred by sustained economic growth, rise in income levels and increased

availability of goods and services. India's commercial energy demand is expected to grow even more rapidly than in the past as it goes down the reform path in order to raise standards of living. A large part of India's population does not have access to commercial energy The 479 kgoe per capita total energy consumption is only about 20 per cent of the global average in 1997 and compared poorly with the per capita consumption of Thailand (1,319 kgoe), Brazil (1,051 kgoe) and China (907 kgoe)(India, 2002b).

Figure 2.2 : Commercial and Non-commercial Energy Supply in India.



Source : 10th Five Year plan, 2002, Planning Commission, GOI.

2.1.3.3 Coal and Lignite

The geological coal reserves of the country are estimated at 220.98 billion tones as on January 2001. Out of this, proven reserves are 84.41 Billion tones, while 98.55 Billion tones are indicated reserves and 38.02 Billion tones are inferred reserves. Coal continues to remain the principal source of commercial energy accounting for nearly 50 per cent of the total

supplies. About 70[1] percent of the power generated is coal and lignite based and this trend is likely to continue in the foreseeable future (India, 2002b).

India has an estimated 1000 billion cubic meters of Coal Bed Methane (CBM), which is likely to emerge as a new source of commercial energy in the country. A demonstration project is under implementation with financial support from the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP). In April, 2001, the Government announced a programme for exploration and production of CBM. Under the first round of bidding, five CBM blocks have been awarded to private companies. Apart from this, exploration work in two blocks has been awarded to two public sector undertakings (PSUs) on nomination basis. The successful implementation of these projects will facilitate exploitation of this clean source of energy.

The current estimates of geological lignite reserves in India are 34.76 bt spread over Tamil Nadu and Pondicherry (87.5 percent), Rajasthan (6.9 percent), Gujarat (4.9 percent), Kerala (0.31 percent) and Jammu and Kashmir (0.37 percent). The lignite deposits in the southern and western regions have emerged as an important source of fuel supply for states like Tamil Nadu, Rajasthan and Gujarat. Over the years, considerable emphasis has been placed on the development of lignite for power generation. Lignite production is likely to increase from 24.3 million tones in 2001-02 to 55.96 million tones in 2006-07 (India, 2002b).

[1] In FY 2000-01 India's total installed capacity was 103134 06 MW consisting of 25574 03 MW (24 79%) hydro, 73273 97 MW (71 04%) thermal, 2860 MW (2 77%) nuclear and 1426 06 MW (1.38%) wind.

2.1.3.4 Oil and Natural Gas

Planning Commission, GOI reported in its 10th Five Year Plan that the latest estimates indicate that India has around 0.4 per cent of the world's proven reserves of crude oil. As against this, the domestic crude consumption is estimated at 2.8 percent of the world's consumption. The balance of recoverable reserves as estimated in the beginning of 2001 is placed at 733.70 million tones of crude and 749.65 billion cubic meters (Bcm) of natural gas. The share of hydrocarbons in the primary commercial energy consumption of the country has been increasing over the years and is presently estimated at 44.9 per cent (36.0 percent for oil and 8.9 percent for natural gas). The demand for oil is likely to increase further during the next two decades as reported by the Planning Commission, India. The transportation sector will be the main driver for the projected increase in oil demand. Consequently import dependence for oil, which is presently about 70 per cent, is likely to increase further during the Tenth and Eleventh (2007-2012) Plans.

India has about 0.4 per cent of world's natural gas reserves. Initially the gas reserves had been developed largely for use as petrochemical feedstock and in the production of fertilizers, but gas is increasingly being used for power generation, industrial applications and more recently in the transport sector. Presently the share of power generation capacity based on gas is about 10 per cent of the total installed capacity. The India Hydrocarbon Vision 2025 of the Government identifies natural gas as the preferred fuel for the future and several options are being explored to increase its supply including building facilities to handle imports of liquefied natural gas (LNG) and setting up of pipelines from major gas producing countries.

Its crude oil production has, however, hit a plateau, no big discoveries having been made in the recent past. Crude oil production in 2001-02 stood at 26.30 million tonnes, marginally lower than the previous year's 26.61 million tonnes. Natural gas production for 2001-02 stood at 25.42 billion cubic metres, up from 25.36 billion cu m in 2000-01(Frontline, 2003)

The discovery by Reliance Industries of a huge gas field in the deep-waters of the Krishna-Godavari basin opens up tremendous possibilities for natural gas as a fuel in India. Yet, the potential of natural gas has never been fully exploited in India, which had an estimated 639 billion cubic metres of reserves till the Reliance discovery (BusinessLine, 2002).

2.1.2.5 Electricity Sector Overview

The total installed generation capacity on 31st March, 2002 was 104917.5 MW. The share of hydel capacity was 25.03%, Steam 59.22%, Gas 10.64%, Nuclear 2.59% and the balance being diesel and wind. Out of total installed capacity, of which 59.33% is owned by the States, 30.12% by Centre and 10.55% is owned by the Private Sector (India, 2002b). India is endowed with economically viable hydro potential. The Central Electricity Authority (CEA) has assessed India's total hydro potential to be about 148700 MW. The hydroelectric capacity currently under operation is about 26000 MW and 16083 MW is under various stages of development. The share of hydro capacity is about 25.03%. The CEA has also identified 56 sites for pumped storage schemes with an estimated aggregate installed capacity of 94000 MW. In addition, a potential of 15000 MW in terms of installed capacity is estimated from small, mini and micro hydel schemes.

Nuclear energy has the potential to meet the future needs of electricity demand in the country. The country has developed the capability to build and operate nuclear power plants observing international standards of safety. The current installed capacity of nuclear power plants is 2860 MW accounting for 2.8 per cent of the total installed power generation capacity in the country. The capacity addition in 2001-02 in Nuclear Power is 880 MW. The Nuclear Power Corporation of India Ltd. (NPCIL) proposes to increase the installed capacity to 9935 MW by 2011-12(NPCIL, 2002). The future strategies focus on a three-stage nuclear power programme for the optimal utilization of the available nuclear energy resources. The first stage of 10000 MW is based on pressurized heavy water reactor (PHWR) using indigenous natural uranium resources. The second stage is proposed to be based on fast breeder reactor (FBR) technology using plutonium extracted by reprocessing of the spent fuel from the first stage. In the third stage, the country's vast thorium resources will be utilized for power generation.

Plant Load Factor of Thermal Power Stations in India has improved during 1997-02 and it increased from a level of 64.4% in 1996-97 to 69.9% in 2001-02. Again the T&D losses increased from a level of 24.53% in 1996-97 to 27.8% in 2001-02. The actual power supply position as on March 2002, as assessed by CEA, indicates a peak deficit of 12.6% and energy deficit of 7.5% at the All India Level as against a peak deficit of 18% and energy deficit of 11.5% during 1996-97. The per capita electricity consumption of the country was 355 Kwh during 1999-2000 as against 334 in 1996-97 (India, 2002b).

India is endowed with abundant natural and renewable resources of energy viz., photovoltaic, wind and biomass. The country has been able to achieve significant capacity addition of 1,367 MW through wind farms and ranks

fifth in the world after Germany, United States, Spain and Denmark in the generation of wind energy **(India, 2002(b))**. Apart from these resources, the country has significant potential for ocean thermal, sea wave power and tidal power.

2.1.4 Nepal

2.1.4.1 Economic Overview

Nepal is among the poorest and least developed countries in the world with nearly half of its population living below the poverty line. Agriculture is the mainstay of the economy, providing a livelihood for over 80 percent of the population and accounting for 41 percent of GDP. Industrial activity mainly involves the processing of agricultural products. Agricultural production is growing by about 5 percent on average as compared with annual population growth of 2.3 percent**(Nepal, 2002)** Nepal has considerable scope for accelerating economic growth by exploiting its potential in hydropower and tourism, areas of recent foreign investment interest. Major economic indicators of Nepal are shown in Table 2.11.

Table 2.11: Economic Overview of Nepal.

GDP at Current Factor Cost in LCU (2001)	379586 mn Rs.
GDP Real growth rate (2001)	4.8%
GDP composition by sector (2001)	
Agriculture	39 1%
Industry	22.0%
Service	38.9%
Average Annual growth of share of GDP (2001)	
Agriculture	4.3%
Industry	2.5%
Services	6.6%

Source : World Bank, 2002

2.1.4.2 Energy Sector Overview

Energy problems of Nepal hardly differ from the ones encountered in other developing countries. Energy sources in Nepal can be broadly classified

into three groups: traditional (biomass), commercial and alternative energy Nepal's rural population has been meeting their energy needs from traditional sources as fuel wood and other biomass resources. The use of commercial forms of energy- electricity, kerosene and diesel - is comparatively new, and in many rural areas these are yet to be introduced. Two major characteristics of energy systems in Nepal are excessive dependence on biomass energy and low efficiency in its use. Diverse energy consumption patterns, due to different geographic, cultural and economic settings and a very low level of energy consumption, as a result of widespread poverty, are some of the other important characteristics. Other aspects that have direct and/or indirect implications on the economic and financial viability of energy systems are people's inability to afford commercial forms of energy and a lack of resources for proper development.

Nepal's per capita annual energy consumption, 0.3 toe (14.06 GJ), is among one of the lowest in the world. Per capita commercial energy consumption, 30 kg of oil equivalent, is also very low compared to other countries of the sub region. However, the growth of commercial energy consumption has been high, about 8.4 percent per annum. The electricity supply is limited to about 14 percent of the total population. The rural population, which makes up about 90 percent of the total, has very limited access to electricity. The rural residential sector alone consumes about 84 percent of the total energy. However, if only commercial energy (including new and renewable energy) is considered, then this figure falls to only 45 percent (WECS, 1997).

In spite of large theoretical hydropower potential of 83000 MW, of which 42000 MW is established to be technically feasible. Nepal has developed only 250 MW of hydropower, which supplies about 1 percent of the total

energy requirements. Fuel wood accounts for 80 percent of energy consumption. Other biomass sources- agricultural residue and animal waste provide for about 10 percent of the energy requirement. Imported petroleum and coal together make up about 8 percent of the total consumption. Current Energy scenario of Nepal is shown in table 2.12(a) and 2.12(b)

Table 2.12(a) : Energy resources and Consumption in Nepal

Estimated Hydropower Potential	83290 MW
Estimated Economic Potential	43000 MW
Installed Capacity (Hydropower)	250 MW
Annual Energy Production (Hydropower)	972 GWh
Installed Capacity (Petroleum)	57 MW
Annual Energy Production (Petroleum)	108 GWh
Electricity Export	63 GWh
Electricity Import	154 GWh
Electricity Purchase	78 GWh
Small and Micrhydro	19 MW

Source: WECS, 1999.

Table 2.12(b) : Energy Scenario in Nepal

Hydropower harnessed (0.3 % of total potential)	253.118 MW
Energy from Thermal Power Stations	60.266 MW
Power supplied in National Grid	248.331 MW
Power from Micro-hydropower centres	4.787 MW
Traditional energy within the total consumption 1997/98	88.9 %
Commercial energy within the total consumption 1997/98	11.1 %
Of the total energy used in 1997/98, traditional sources consists of	
Energy from fuelwood	79.4 %
Energy from agriculture end products	3.6 %
Energy from animal end products	5.9 %
Of the total energy used in 1997/98, commercial sources consists of	
Energy from Petroleum Products	7.8 %
Energy from Coal	2.3 %
Energy from electricity	1 %

Source: Nepal, 2001.

2.1.4.3. Electricity Sector Overview

Nepal is well endowed with enormous hydro-power resources. By the end of 1997-98 hydro power generation reached 261.918 MW in the country.

In order to meet increasing demand of power steps will be taken to consolidate and strengthen existing generating facilities with a view to increase efficiency in production and distribution of energy. Medium size hydro-power projects such as Khimti (60 MW), Indrawati (5 MW), Upper Bhotekoshi (36 MW) have already been taken up by the private sector[2]. Other major projects on which preliminary studies have been undertaken include (Chisapani) 10800 MW, Upper Arun 335 MW, Pancheshwor 6480 MW, Lower Arun 308 MW, and Upper Karnali 300 MW hydro electric projects. Another major project West Seti Hydel project (750 MW), is being taken up by a private sector (SMEC West Seti Hydroelectric Corporation).

Nepal has roughly 83290 MW of hydropower potential, half of which is ecnomically feasible for development.Less then 1% of this capacity has been developed. Demand for power in Nepal is outstripping supply by 25 MW or 10 percent per year. The domestic energy demand, currently at 270 MW, is expected to rise to 610 MW by 2005 as forecasted by NEA.

[2] Nepal is the first country to introduce Private player in Hydro electric power sector in this region (SAGQ)

Chapter 3

Energy and Economic development

3.0 Introduction

Energy is considered as the prime mover of the economic development. Traditionally energy has been regarded as the engine of economic progress. In this chapter, we bring out importance of energy, especially electricity in economic development. The consumption of Non-commercial and commercial energy in different sector and the effect of energy prices are also discussed in this chapter.

Most of the underdeveloped and developing countries rely significantly on non-commercial energy like fuel wood, cow dung and biomass etc. Table 3.1 reports the commercial energy use per capita for Bangladesh, Bhutan, India and Nepal. As economic development takes place, non-commercial fuels are replaced with the commercial sources of energy like coal, electricity, petroleum and natural gas etc.

Commercial energy consumption per capita in India is the highest among the four neighboring countries

Table 3.1 : Commercial Energy use per capita (kg oil equivalent)

Country	1971	1975	1980	1985	1990	1995	1999
Bangladesh	112	117	126	131	145	159	140
Bhutan*	NA	2	NA	19	57@	NA	NA
India	328	340	353	385	424	475	482
Nepal	222	224	331	325	324	334	350

Source : WDI. , *FAO, @ 1992 data

In the context of an economy, energy is primarily used in agricultural, industrial, Transportation and services as well as directly by households. Energy consumption is closely linked with many other economic indicators, such as population growth, GDP growth, and various importance of economic activities in the economy.

The relationship between energy and economic development can be understood in the following way. As economies grow, share of industrial output in GDP tends to grow and that for agriculture tends to decline and the former being more energy intensive than the later. Hence, we need to rely on availability of energy to fuel of economic growth.

3.1 Energy demand and GDP

Gross Domestic Product is the readily available economic indicator. It has a strong relationship with the consumption of energy especially during early phase of economic development Increase of level of energy consumption is linked to growth of GDP. The figure 3.2 shows the GDP growth and the electricity consumption growth for the different countries.

Table 3.2 : % Growth of Electricity consumption and GDP

Country	% growth of GDP[@]						% growth of Electricity consumption[$]					
	1995	1996	1997	1998	1999	2000	1995	1996	1997	1998	1999	2000
Bangladesh	4.9	4.6	5.4	5.2	4.9	5.9	10.66	5.79	3.36	6.01	10.87	0.93
Bhutan	7.4	6	7.3	5.5	5.9	6.1	5.05	69.4	8.26	-21.4	-0.45	8.01
India	4.2	8.1	4.8	6.6	6.4	5.2	5.82	5.12	2.74	4.87	4.6	3.89
Nepal	3.5	5.3	5	3	4.4	5.8	6.47	4.32	5.29	4.77	-2.71	14.64

Source : @ Key Indicators, ADB, 2001 $ Calculated by the author from the data compiled from Key Indicators, ADB, 2001.

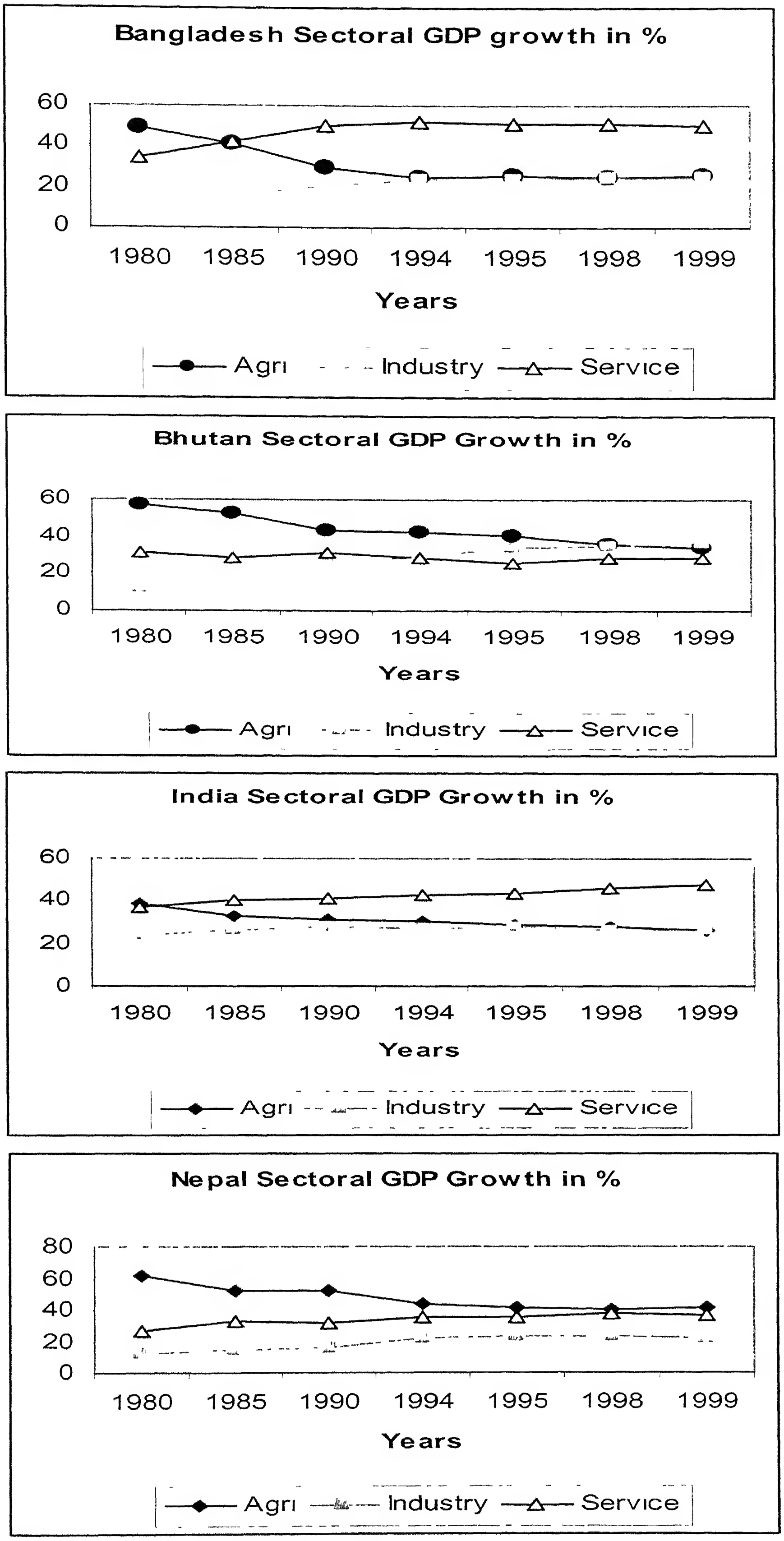
Energy intensity measured as the ratio of primary commercial energy consumed to GDP is reported in table 3.3. Energy intensity of India in this region is the highest and that for Nepal is the lowest.

Table 3.3 : Ratio of total primary energy consumed to GDP at constant price

Country	Energy Intensity in GDP (toe/'000 1993 US$)				
	1975[#]	1980[#]	1985[@]	1990[@]	1997[@]
Bangladesh	0.14	0.21	0.24	0.21	0.25
Bhutan	NA	NA	0.17	0.26	0.41
India	0.57	0.64	0.74	0.79	0.87
Nepal	0.09	0.12	0.12	0.08	0.16

Source : # Energy Indicator, ADB @ Key Indicators, ADB

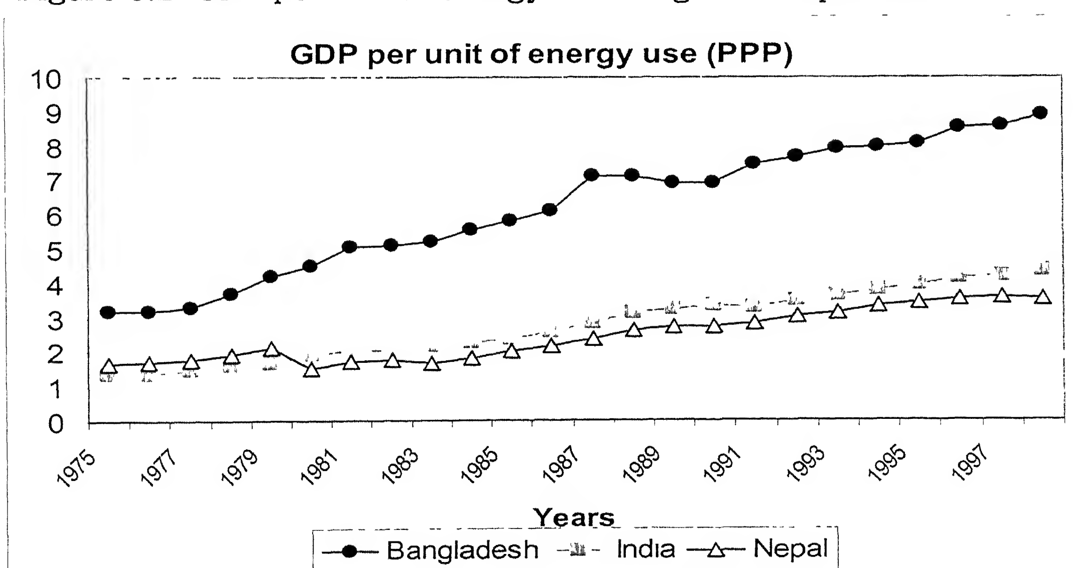
Figure 3.1: Share of GDP in different countries.



Source : World Resource Institute, 2002

growth, especially in developing countries, is accompanied by increase in energy consumption. Apart from this change in structure of GDP also has significant impact on energy consumption. As less energy intensive agriculture share of GDP is taken over by every industry intensive activity, the level of energy consumption in the economy is expected to increase GDP share in different sectors for countries in SAGQ region are reported in figure 3.1. For all these countries agricultural GDP share is decreasing gradually. But on the other hand Industrial and Service sector GDP share are increasing. Another significant point to be noted here is that the economy of these four countries is agriculture based. For Bangladesh, average agricultural share of GDP for these years are 35~45 percent. Similarly for Bhutan and Nepal also it is approximately 45~55 percent. Same trend follows in the Indian case also. This clearly indicates that Service sector and industry sector is growing faster than the agricultural sector. From Figure 3.8, it is also clear that the industrial energy consumption is increasing for all these countries. This GDP share of different sector is having a direct relationship with the consumption of energy.

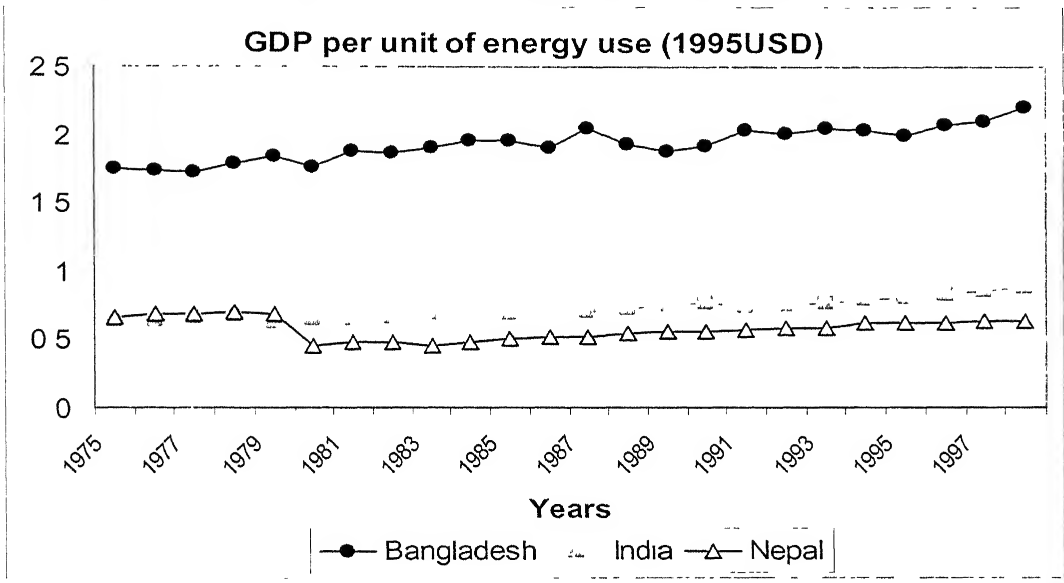
Figure 3.2: GDP per unit of energy use in kg of oil equivalent



Source : WDI, 2000

GDP per unit of energy use is the highest in Bangladesh amongst all the other countries in the sub-continent. This is shown in figure 3.2 and figure 3.3. But, another factor is that, energy exchange rates used to express GDP are sometimes misleading. This is because currency rates are often affected by the financial markets and trade policies of the different countries. Therefore in most of the cases to estimate energy intensity, purchasing power parity (PPP) is used. For example GDP per unit of energy use (1995 US$) in 1998 in India is 0 886 kg oil equivalent and that in PPP unit is 4.345 kg oil of equivalent.

Figure 3.3: GDP per unit of energy use (1995 USD) in kgoe



Source : WDI, 2000

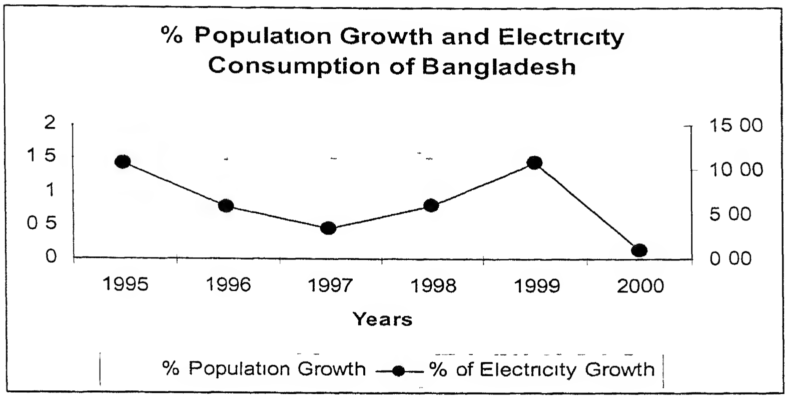
3.2 Electricity Consumption and Population Growth.

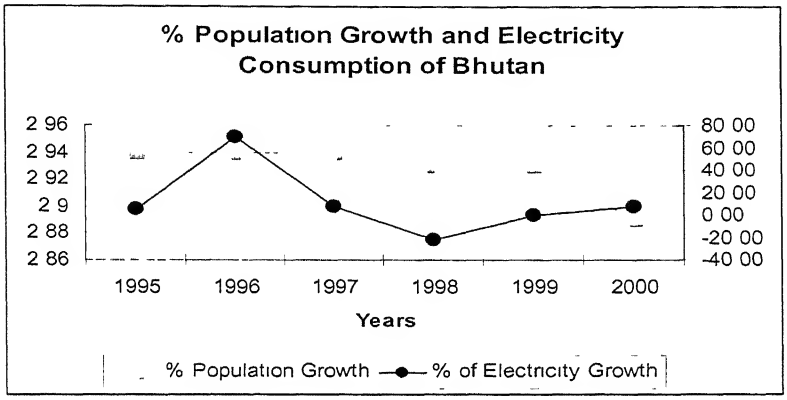
The growth of population has a significant impact on the electricity consumption. This growth of population directly effects the household sector energy consumption scenario. Another significant point is to be noted here that this energy consumed by this sector for these countries

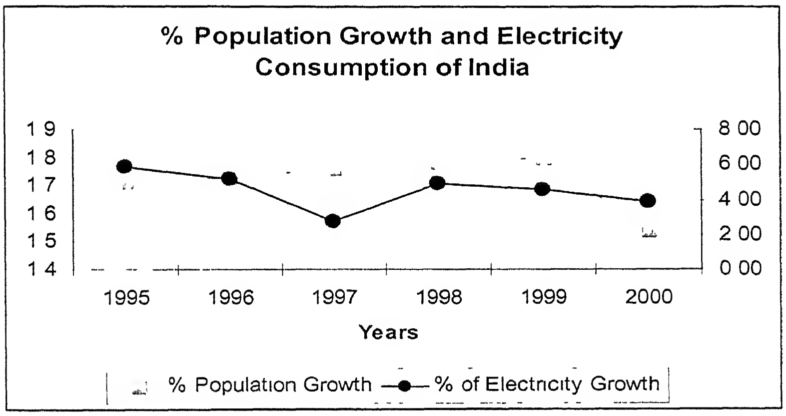
This relationship of population growth and energy consumption is shown in Figure 3.4. Population growth is merely constant up to 1999 and declines after 1999 for Bangladesh, Bhutan and Nepal to 2000 and this is shown in figure 1.2 in Chapter 1. Electricity growth declined in case of Bangladesh after 1999. But, for the other countries like Bhutan, India and Nepal electricity consumption increased after 1999. The trend of electricity consumption in the household sector increased from the year 1997 onwards.

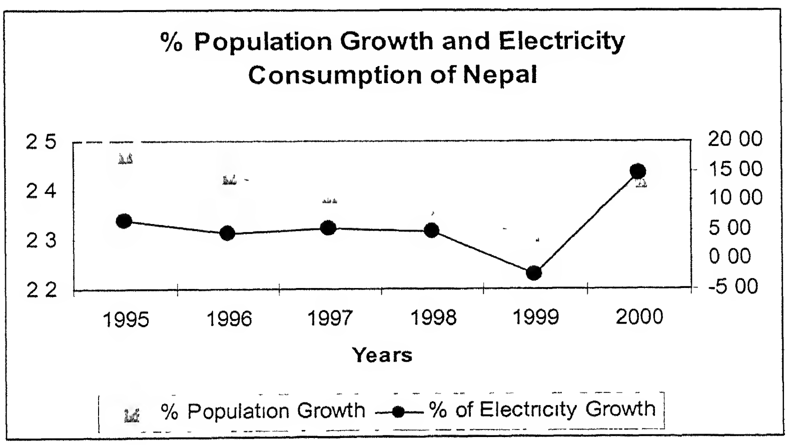
3.3 Energy Consumption and Energy Prices

Prices of energy have a significant impact on the energy consumption. According to the demand theory, effect of price variation has two distinct effect of substitution and income effect. Fall of price of one type of energy has two distinct effects, one is change in relative prices i.e. shift consumption toward cheaper type of energy or the substitution among various types of energy and away from more expensive energy and the other is change in real income i.e. lower price give consumer greater buying power. On the other hand the same can be expressed as the effect of income as when income raises consumer changes the amount of energy consumption.









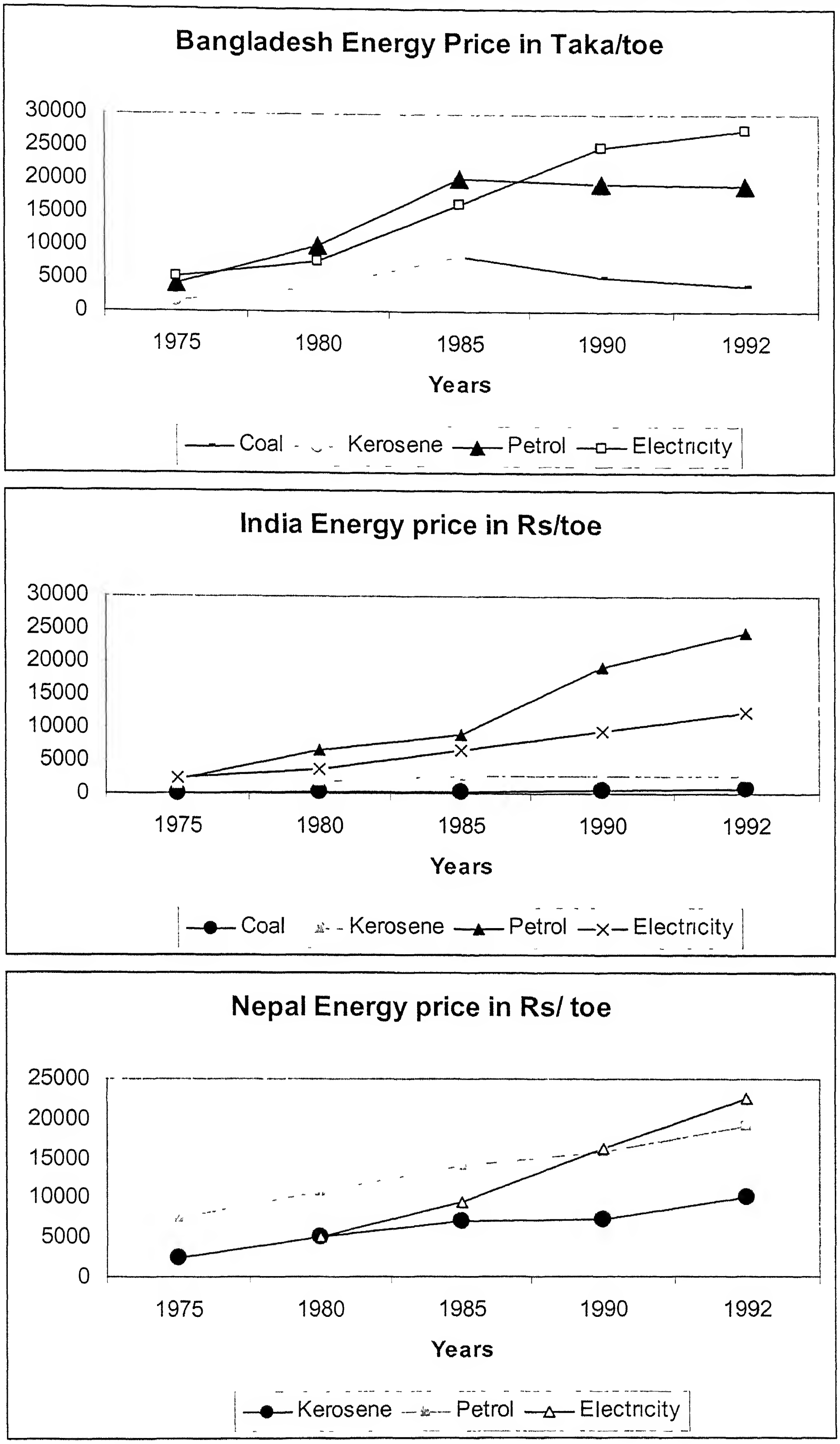
Source : WDI, 2000 (calculated by the author)

Another significant effect of energy consumption is the energy pricing policies. For different countries, energy pricing policies are different. This energy pricing policy covers the different pricing slabs for different consumers and cross subsidies over different sectors like industry and agriculture. For example, in India agricultural use of electricity is much cheaper than the other use and similarly, for small, medium and large industries the electricity pricing slabs are also different. This has the direct effect on the energy consumption.

Currency value and economic reforms also have certain impacts on the energy pricing and these effects energy consumption. Now referring to Figure 3.5, price of electricity is higher than coal and other types of energy in Bangladesh. Another point to be noted here is that electricity price for India is increasing at a constant rate but the price of petrol is increasing higher than other types of energy. For Nepal again, electricity price is higher than petrol and coal.

In summery, for all these countries electricity price is increasing very high rate than coal and other commercial energy. For Bangladesh, prices of coal is decreasing over the years but the electricity price is increasing. For India the pace of growing price from year 1975 to 1980 was slow but after 1980 it increased almost linearly. For Nepal also after 1985, electricity price is increasing linearly. From figure 3.1 it is also clear that the electricity growth also decreased for some years in early 90s.

Figure 3.5 : Energy Prices of Different countries in Local Currency.

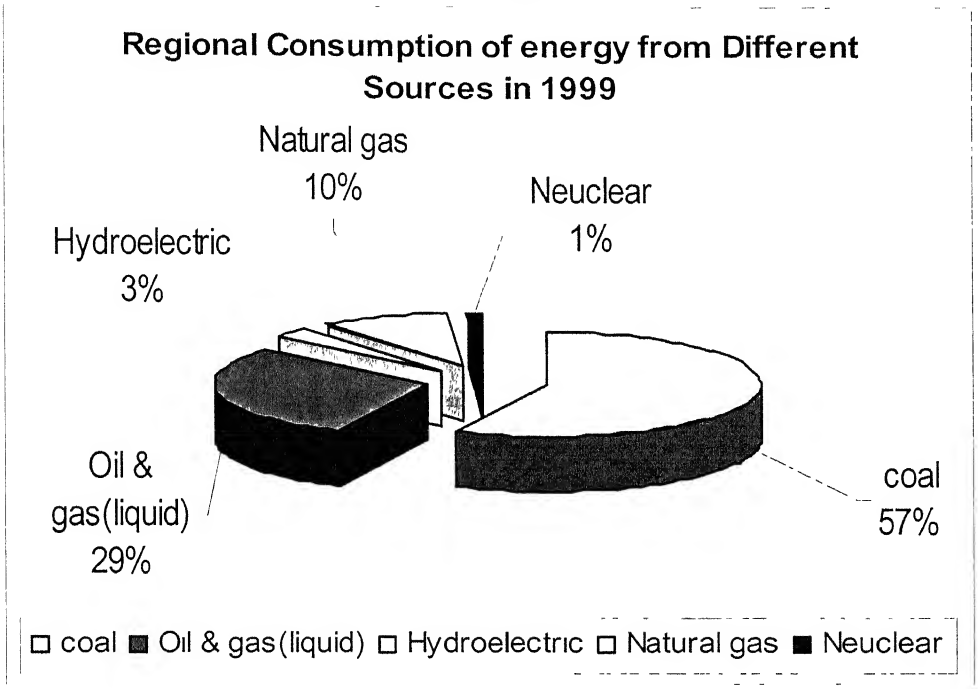


Source : ADB, 1994.

3.4 Supply and Demand Scenario in the Region

The commercial energy consumption is coal (57%) dominated in this South Asian region[1] This is clearly visible from the Figure 3.6. The next dominated energy source is oil and gas with 29%.

Figure 3.6 : Regional Supply of Energy from Different Sources in 1999.



Source · WRI, 2002

In Figure 3.7 and Figure 3.8, sectoral energy consumption for these countries are reported. Natural gas consumption is the highest in Bangladesh. Another interesting observation is that in 1971, most of the energy consumed in the South Asian region was mostly non-commercial energy. All the energy sources including coal, hydro and natural gas is increasing in this region gradually. For Nepal, still, the commercial energy sector is not growing. The hydro electric sector in Nepal is under

[1] All the different energy sources like Coal, Hydro, Nuclear etc in common units (in mtoe) are added together for all these four countries and then calculated the regional consumption

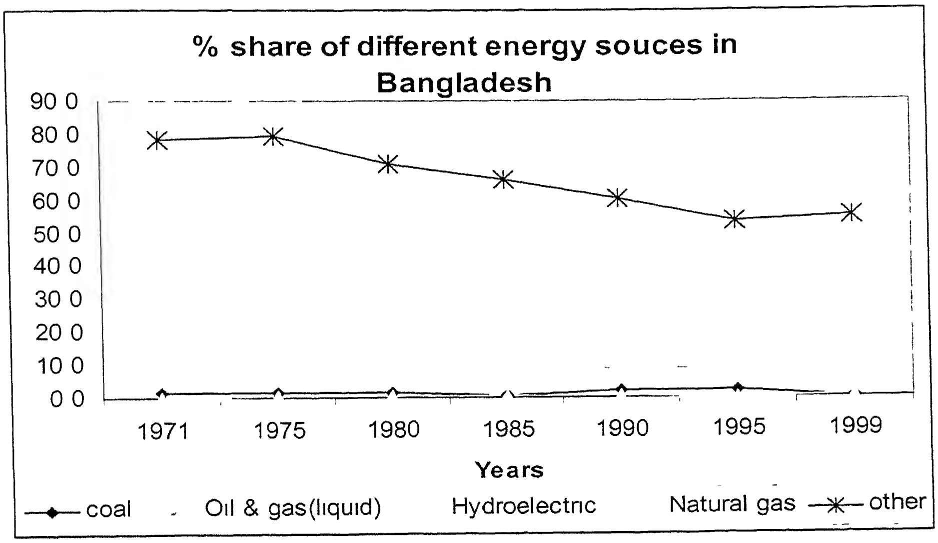
developed and similarly, in Bangladesh, Natural gas sector is under developed. This is already discussed in section 2.1.1.4 and section 2.1.4.3.

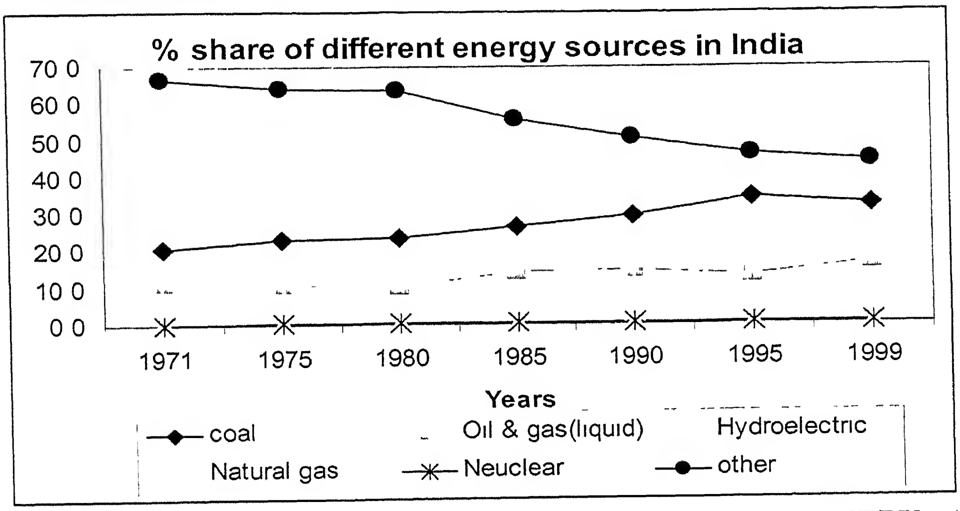
Figure 3 8 reports the sectoral consumption of energy in agriculture, industry, residential and transport sector for different years. In 1971 and later 80s residential energy consumption in Bangladesh decreased considerably. In 1970s most of the commercial energy consumed in Bangladesh was in residential sector. In 1999 Energy consumed in Industrial sector in Bangladesh is 20.75 percent. It has increased significantly from 8.75 percent in 1971.

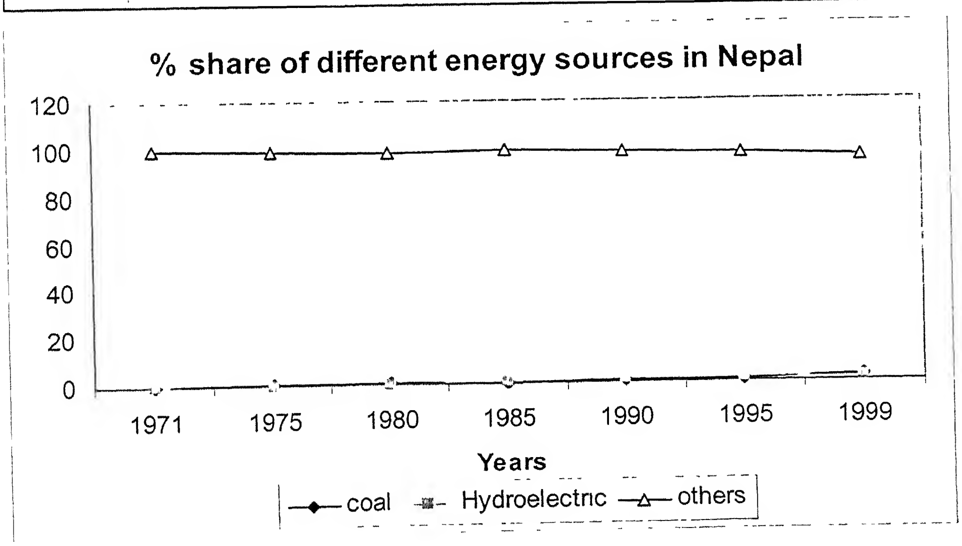
Indian scenario is different from other countries. Energy share is increasing in all the sectors gradually from 1971 to 1999. approximately 50 percent commercial energy consumed in India by the residential sector only.

Nepal is showing a very slow progress in energy consumption in Agriculture, Industrial and transport sector. Most of the commercial energy is consumed by the household sector only.

Figure 3.7 : Consumption from different sources.

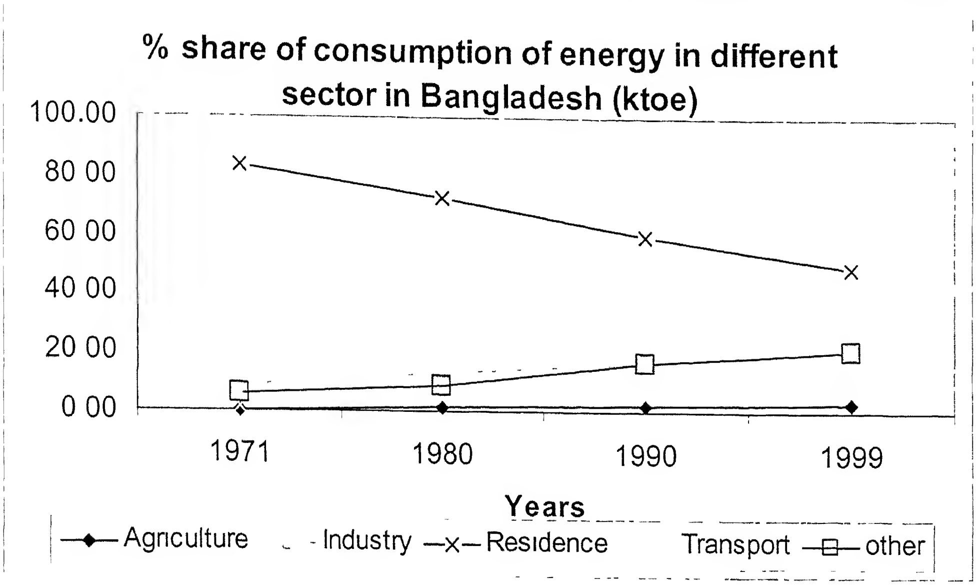


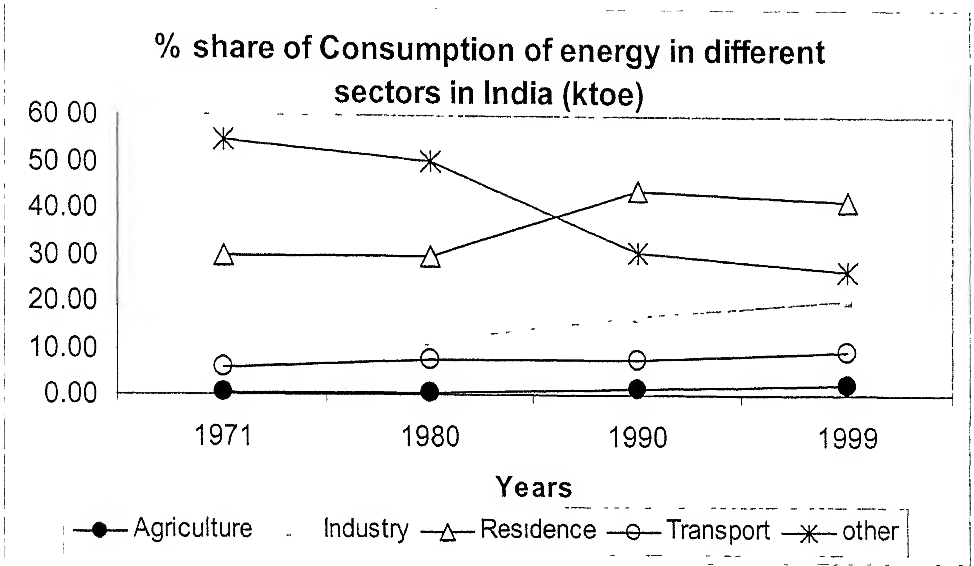


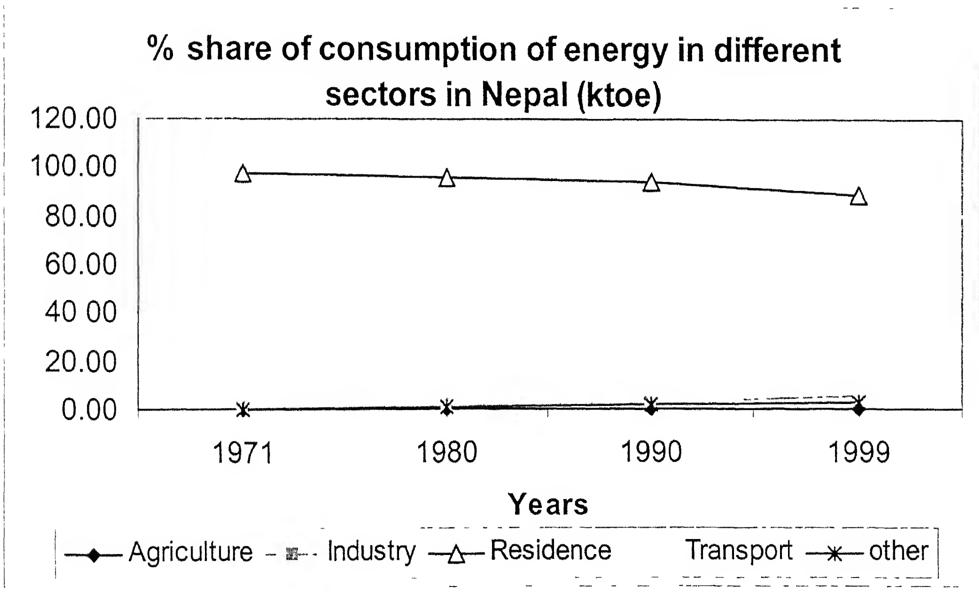


Source: WRI, 2002.

Figure : 3.8 Energy consumed in Different sector (1971-1999)







Source: WRI, 2002

Chapter 4

Electricity Demand Analysis and Forecasting

4.0 Introduction

The consumption of commercial energy has been rapidly increasing in the South Asian region, which aggravated the present energy mismatch and disparity. In this chapter, econometric models for electricity demand have been developed. The developed model is used to forecast electricity demand until 2015. Towards the end, based on the projected electricity demand in 2006-07 and projected availability of electricity based on planned capacity addition by the public sector and expected private investment.

4.1 Literature Survey

Owing to numerous uncertainties involved, the exercise of demand modeling is inherently complex. In this chapter we develop a electricity demand model for all these countries viz, Bangladesh, Bhutan, India and Nepal. Electricity demand models based on the intensity of consumption have been developed to analyze the demand patterns in Brazil and Holland using the intensity of energy technique (Furtado and Suslick, 1993; Harry, 1998). Glakpe et al., (1985) has suggested a simple procedure for forecasting model for electricity requirement in the developing countries of West Africa. He also assumed that each year's use will be a certain percentage greater than the previous year's consumption (Harry, 1998). Casely-Hayford, (1976) also developed a model by using historical data based on electricity use and population growth to develop national electricity production model in Ghana. Galli, (1998) discussed a quadratic model and a log linear model and suggests that quadratic model performs well over log linear. Galli, (1998) also cited that energy demand is a non-monotonic (quadratic) function of income and energy prices. He used

resource intensity i.e. consumption of physical resources per unit of GDP with GDP growth and Energy used per capita growth over 12 years for forecasting of long term energy demand in Asian emerging countries. Chan and Lee, (1996) used a forecast model for China using regression model with co integration and vector correction method. The simplest approach for energy demand modeling is Time-Series trend analysis for Israel selecting time as a single independent variable (Bargur and Mandel, 1981).

Modern computational techniques using genetic algorithm and artificial neural network also have been recently adapted to frame demand models (Chaturvedi et al., 1995) Spyros et al., (1978) again reported that many of these methods require complex computational efforts and the accuracy is seriously restricted by prior subjective prejudices. Econometric models that correlate the energy demand with other macro-economic variables have been proved to be very effective in analyzing the energy-consumption pattern of developing countries (Rao and Parikh, 1996; Sengupta, 1993). Multivariate time series models using Bayesian vector auto regressions to 2010 exploit dynamic patterns in groups of economic variables for energy forecast for Western Australia (Charleson and Weber, 1993). This model generates energy forecast using data as energy consumption, energy price and aggregate output of historical data. Another important issue that should be considered in forecasting energy demand is the energy price (Hammond et al., 1973). (Hirschhausen and Andres, 2000) also used GDP growth, primary energy demand and growth and, electricity demand with real price electricity to forecast China's long term demand. They also used three different scenarios of growth levels in the forecasting.

4.2 Electricity Demand Model

Consumption of electricity depends broadly on two different factors as proposed in this chapter. One is economic growth and the other is price of electricity. Readily available indicator of economic growth is the GDP and the income indicator is the per capita income. The effect of GDP and Price on energy consumption is already discussed in section 3.1 and 3.3 respectively. As already discussed, price of electricity relative to price of other energy types also has a substitution effect for the demand analysis. Apart from level of income, structure of economic activities as reflected by share of agriculture, industry and services sectors, also has a bearing level of energy consumption.

To propose an electricity demand model, all the above discussed factors effecting the consumption of electricity is taken care of. Demand theory says that the price is the basic indicator for consumption of goods. We are taking the price index for power, fuel, light and lubricant as one factor of consumption of electricity in demand forecasting. Per capita GDP is considered as an indicator for income in the model.

The following functional relationship for the demand of electricity is proposed for estimation. The relationship is assumed to be linear. We write the multiple regression model as:

Per capita consumption of electricity (E) is considered to be dependent on per capita GDP (G), structure of GDP and real price of electricity. Time varies behavioral changes in consumption of electricity are assumed to be dependent on time index t. To represent structure of GDP, % share of GDP-Industry (I) and % Share of GDP-Agriculture (A) are considered. Real price of electricity (P) is the ratio of price index of energy to price index of all commodities.

This relation can be expressed as,

$E = f(t, G, I, A, P)$ .... (4.1)

Assuming a linear functional relationship model expressed in (4.1) can be written as,

$E = a_0 + a_1 t + a_2 G_t + a_3 I_t + a_4 A_t + a_5 P_t$ .... (4.2)

A log linear relationship can be expressed as,

$ln\ E = h\ (ln\ t, ln\ G, ln\ I, ln\ A, ln\ P)$ .... (4.3)

Considering the log relationship to be linear, we get the log-linear form as below.

$lnE = b_0 + b_1 lnt + b_2 lnG_t + b_3 lnI_t + b_4 lnA_t + b_5 lnP_t$ .... (4.4)

Where, b_i are coefficients of the model that directly provide elasticity values with respect to each of the individual factors.

Equation (4.4) is proposed for estimating demand of electricity for these countries. Individual plotting of dependent variable with respect to the alternative independent variable depicts a non linear trend hence a log linear relationship was chosen as an appropriate model. The model can be estimated using Least square method after appending error term to the model 4.4.

4.3 Data Limitations

We have the time series data for Bangladesh, Bhutan, India and Nepal for all the economic and other indicators like GDP in Constant (1995) Local Currency Units (LCU), Share of GDP (Agriculture), Share of GDP(Industry) and per capita consumption of Electricity. These data are used for estimation of parameters in the later part of this chapter.

For Bangladesh and India we have all data for these indicators starting from 1971 to 2000. But for Bhutan and Nepal, this data have from 1983 to 2000 and from 1971 to 1999 respectively. Another major limitation is to get the price of electricity or the price index of electricity for these years. Price index of electricity or power is very much important factor to be considered for demand analysis. Time series data of price index of fuel and power is available only for India for 30 year period. This is used in the analysis. In India context, ratio of price index of electricity to WPI for all commodities is used to represent real price electricity. For Bangladesh, Bhutan and Nepal, we have only electricity price data from 1991 onwards and these series data could not used for analysis. Due to this limitation, we use a electricity demand model without price index of electricity for these countries.

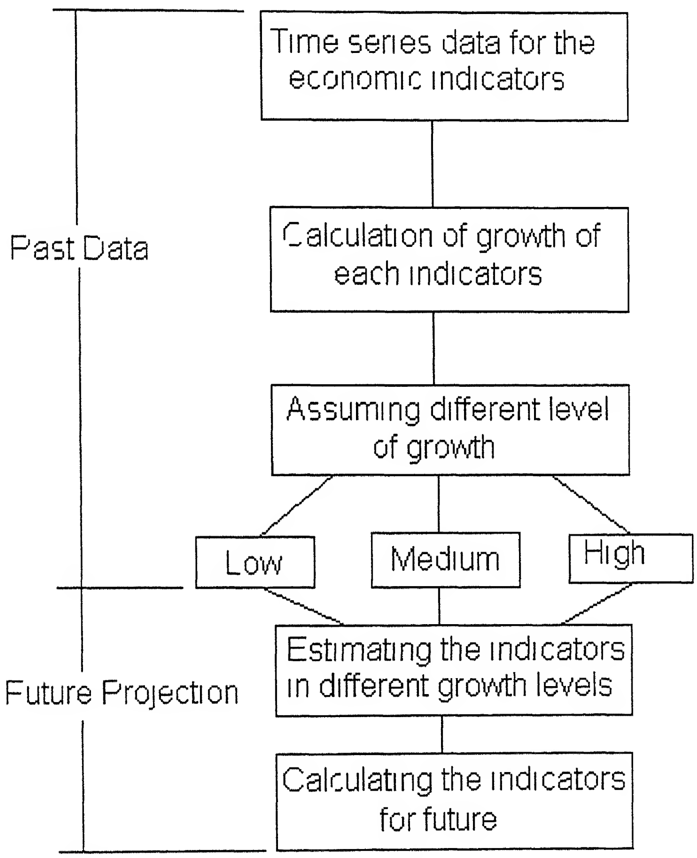
Moreover, domestic inflation also have direct or indirect effect on the measure of GDP per capita. In our analysis we are using constant LCU for the GDP and this problem does not arise. This model does not consider any government subsidy or any government policy regarding the electricity sector.

4.4 Forecasting Methodology and Assumption

Econometric estimation of the electricity demand model gives us parameter values with certain degree of confidence. This model can be used to forecast electricity demand in the four countries. The proposed method is depicted in figure 4.1 below. To forecast total electricity consumption, we need forecasted per capita electricity consumption as well as forecasted population for the target years. For population forecast, we use WRI

projections for forecasting per capita electricity consumption we need forecasted values of per capita GDP, GDP share of agriculture and industry and price index for electricity. Projection of future GDP is one of the most crucial variable in the model. To account for diverse assessment of future economic outlook, we consider three scenarios for economic growth – low growth, medium growth and high growth scenario forecasting assumptions for each of the four countries is discussed separately in the following sections.

Figure 4.1 : Estimation of parameters

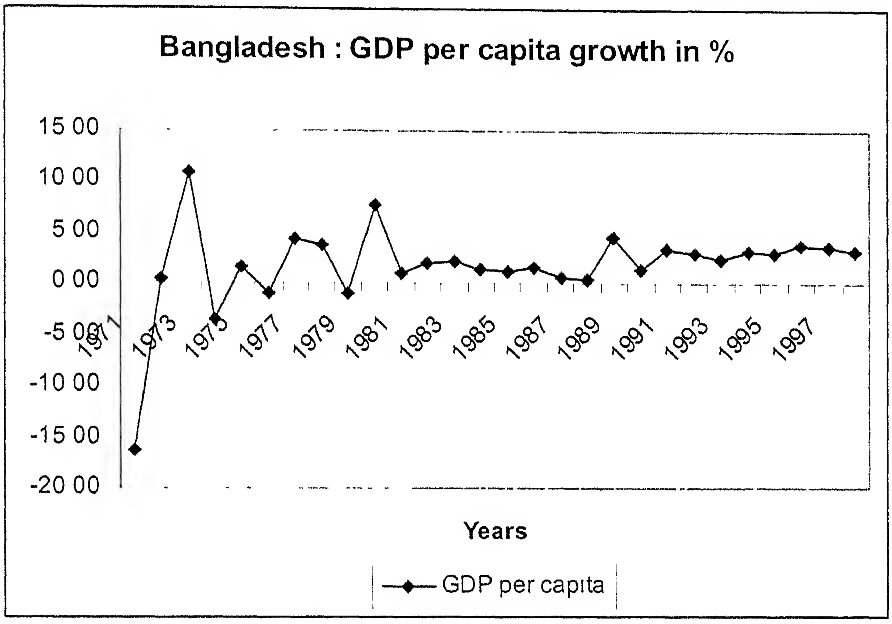


4.4.1 Bangladesh

The growth rates of GDP per capita in constant LCU for Bangladesh in percentage is shown in figure 4.2. This depicted that the average annual GDP growth from 1971 to 1999 has been 1.76 percent Growth rate has

been increased higher in 90's Average growth from 1991 to 1999 is 3.19 percent. GDP share of agriculture, industry and service in percentage is shown in figure 3.1. Growth of GDP share of agriculture is decreasing but the growth of industry and service sector share is increasing. The average growth of share of GDP (agriculture) from 1971 to 1999 is -2.16, i.e. negative but the same from 1991 to 1999 is -1.92. Again the same for the industry sector from 1971 to 1999 is 4.63 and from 1991 to 1999 is 1.66. Again the population growth varies in between 1.5 to 2.5 percent with an average of 1.92 percent Different level of growth for parameters is given in table 4.1.

Figure 4.2: GDP per capita growth in percentage for Bangladesh.



Source : WRI, 2001

Table 4.1 : Growth levels Assumption for Bangladesh (in %).

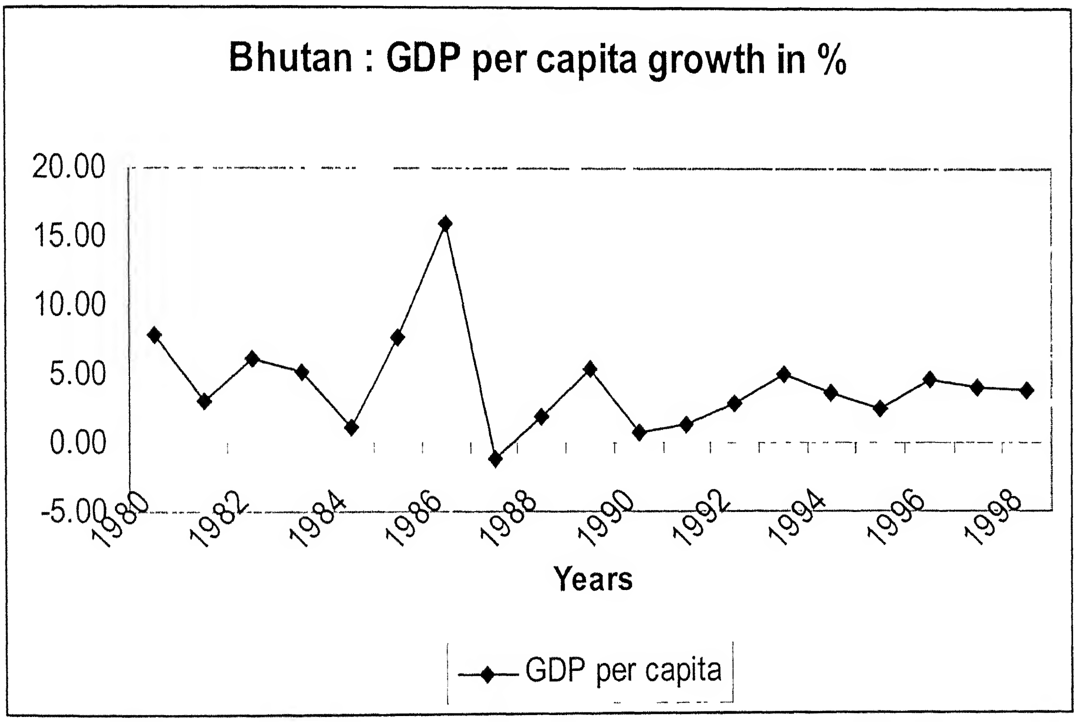
Variables	Low growth	Medium growth	high growth
Per capita GDP (constant LCU, 1995)	2.5	3.5	4.5
Share of GDP (Agriculture)	-2.5		
Share of GDP (Industry)	3.5		
Population growth	1.919 #		

Note: # WRI, 2001

4.4.2 Bhutan

For Bhutan, growth of GDP per capita is shown in figure 4.3. In 1987, the growth is highest and the average growth from 1980 to 1999 is 4.32. The trend varies in between 2.5 - 5.0 percent. Similarly, the growth of GDP share in agriculture sector varies between -3.00 percent to -2.5 percent during these years. Agriculture share of GDP is decreasing but the industry and service sector GDP share is increasing. The same for the industry share varies between 4.4 to 6.5 percent and the average growth is 6.43 percent. The share of GDP is shown in figure 3.1. Population growth in Bhutan is not very high and it varies from 1.28 to 2.84 percent in different years. The average population growth from 1980 to 1999 is 2.29 percent. Different levels of growth are considered for the estimation of the parameters and are shown in table 4.2.

Figure 4.3 : GDP per capita growth in percentage for Bhutan.



Source : WRI, 2001

Table 4.2 : Growth levels Assumption for Bhutan (in %).

Variables	Low growth	Medium growth	high growth
Per capita GDP (constant LCU, 1995)	2.5	3.5	4.5
Share of GDP (Agriculture)	-2.5		
Share of GDP (Industry)	6 43		
Population growth	2.65#		

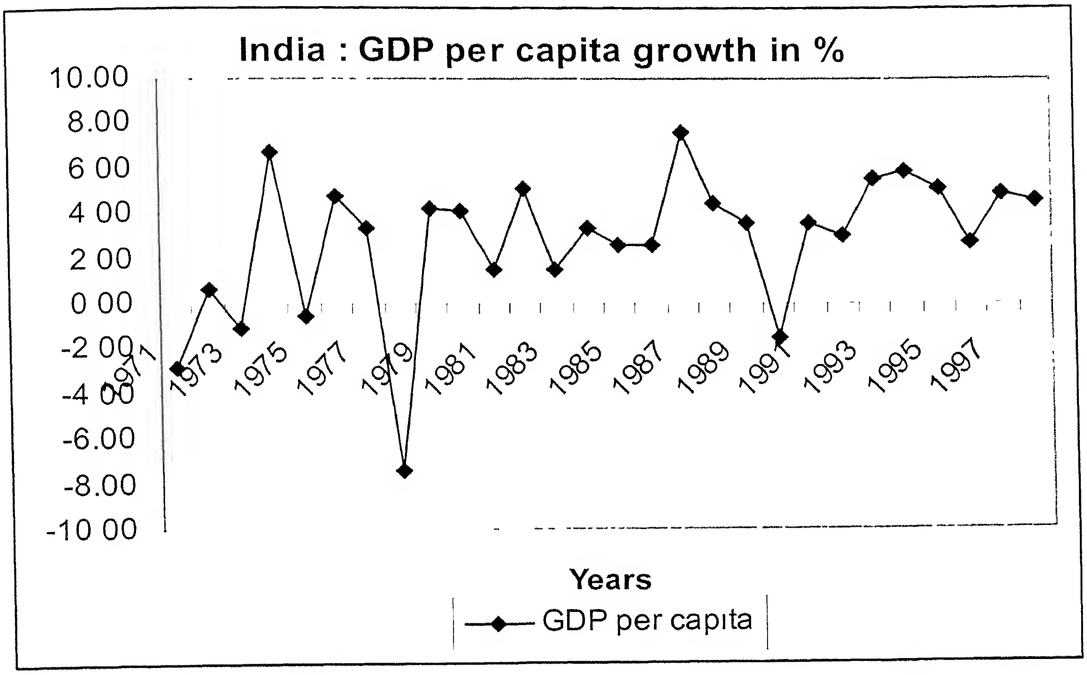
Note : # WRI, 2001

4.4.3 India

For India growth of GDP per capita is shown in figure 4.4. In 1978 the growth is lowest and in 1988 the growth is highest and the average growth from 1971 to 1999 is 2.79 percent. But the trend is considerably increasing in 90's. The trend varies in between 2.5 – 5.0 percent. We assume different level of economic development considering three levels. Similarly, the growth of GDP share in agriculture sector varies between 0.00 to -6.5 percent during these years with a average of approximately -2.00 percent. Agriculture share of GDP is decreasing but the industry and service sector GDP share is increasing and this is shown in figure 3.1 in the earlier chapter. The growth of GDP share of industry also varies between 0.00 to 2.5 percent and the average growth is 1.05 percent. The price index of fuel, power and light is increasing very high in India. We have considered the 1994 price as the basis and it increases approximately 900 percent from 1971 to 2000. In the initial years the variation was very high but after 1982 the variation decreases. Growth of WPI (fuel, power and electricity) and growth of WPI (all commodities are shown in figure 4.5. The variation of WPI (fuel, power, light and lubricant) is similar with variation of WPI (all commodities). The trend of variation is merely constant but declining over the recent years and growth variation is lowest for both the indicators. Population growth in India is not very high and is lowest in this region and it varies from 1.28 to 2.84 percent in different

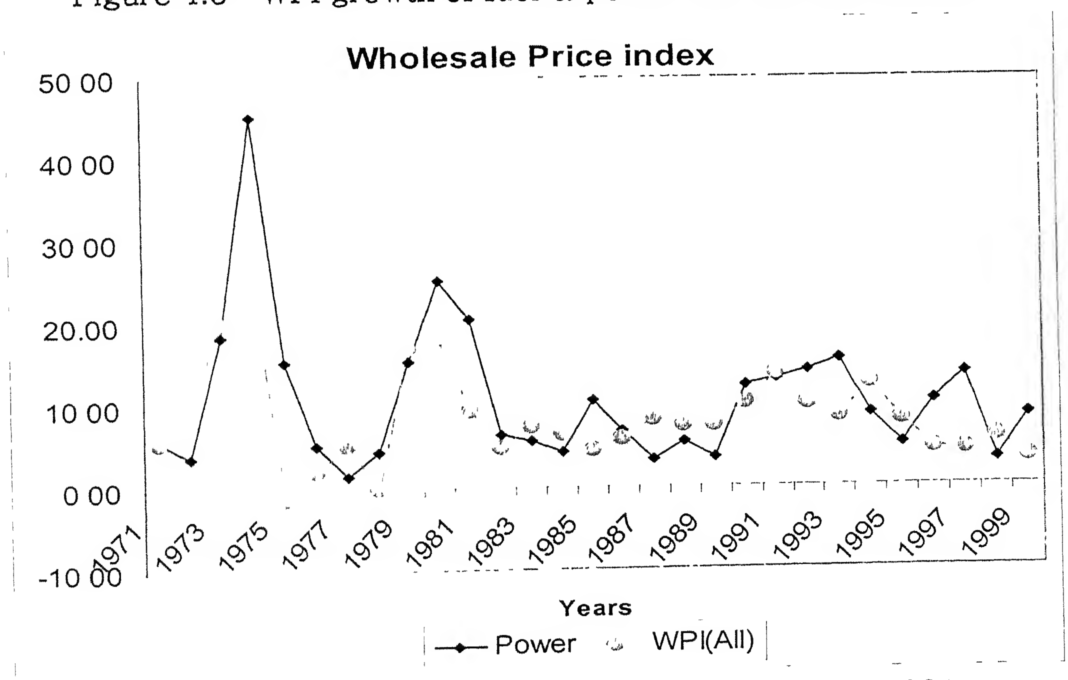
years. The average population growth from 1971 to 1999 is 2.08 percent and is having a decreasing trend in the recent years. Different levels of growth are considered for the estimation of the parameters and are shown in table 4.3.

Figure 4.4 : GDP per capita growth in percentage for India.



Source · WRI, 2001

Figure 4.5 : WPI growth of fuel & power and all commodities



Source : Reserve Bank of India, handbook of statistics, 2001

Table 4.3 : Growth levels Assumption for India (in %).

Growth of variables in %	Low growth	Medium growth	high growth
Per capita GDP (constant LCU, 1995)	4.00	4.50	5.50
Share of GDP (Agriculture)		-2.50	
Share of GDP (Industry)		1.50	
WPI (Power etc)/ WPI (All Commodities)		10.00	
Population growth in		1.293#	

WRI, 2001

4.4.4 Nepal

The growth of GDP per capita in constant LCU for Nepal in percentage is shown in figure 4.6. This depicted that the average growth from 1971 to 1999 is 1.48 percent. But this growth increases after 1987 and the trend is positive growth in 90's. Average growth from 1991 to 1999 is 2.10 percent. GDP share of agriculture, industry and service in percentage is shown in figure 3.1. Growth of GDP share of agriculture is decreasing but the growth of industry and service sector share is increasing. The average growth of share of GDP (agriculture) from 1971 to 1999 is -1.71, i.e. negative but the same from 1991 to 1999 is -2.02. This indicates that the trend is decreasing slightly over years. Again the same for the industry sector from 1971 to 1999 is 2.77 and from 1991 to 1999 is 2.66. This clearly shows that the rapid industrial growth. Again the population growth varies in between 2.3 to 2.6 percent from 1971 to 1999 and roughly constant. We assume a lower population growth for Nepal. We have shown the different level of growth for calculation of these variables in table 4.4.

4.5.1 Bangladesh

A model for electricity demand as described in section 4.2 is estimated using time series data from 1971 to 2000. The results are reported below.

We have estimated taking different sets of equations with different combinations of independent variables to get the desired forecast for future projections. Initially, the basic equation is used with all the independent parameters like GDP per capita (constant 1995 LCU), share of GDP (agriculture), share of GDP(industry) and time. The b_i values are reported in table 4.5.

Table 4.5 : Demand equation estimated coefficients of Bangladesh

Regression model	Intercept	GDP per capita (constant LCU)	share of GDP (Agri)	share of GDP (Ind)	time	R^2
1	-13.1297 (-2.8163)**	1.8814 (4.6647)**	-0.4149 (-1.6053)	-0.0205 (-0.1182)	0.2598 (3.090)**	0.975
2	-13.296 (-3.0497)**	1.890283 (4.8614)**	-0.40381 (-1.70936)*	---	0.2543 (5.4307)**	0.975
3	-20.0225 (-10.704)**	2.432568 (11.1546)**	---	0.080662 (0.48361)	0.25149 (3.6840)**	0.972
4	-20.1031 (-10.946)**	2.4594 (11.8289)**	---	---	0.2752 (5.8827)**	0.972

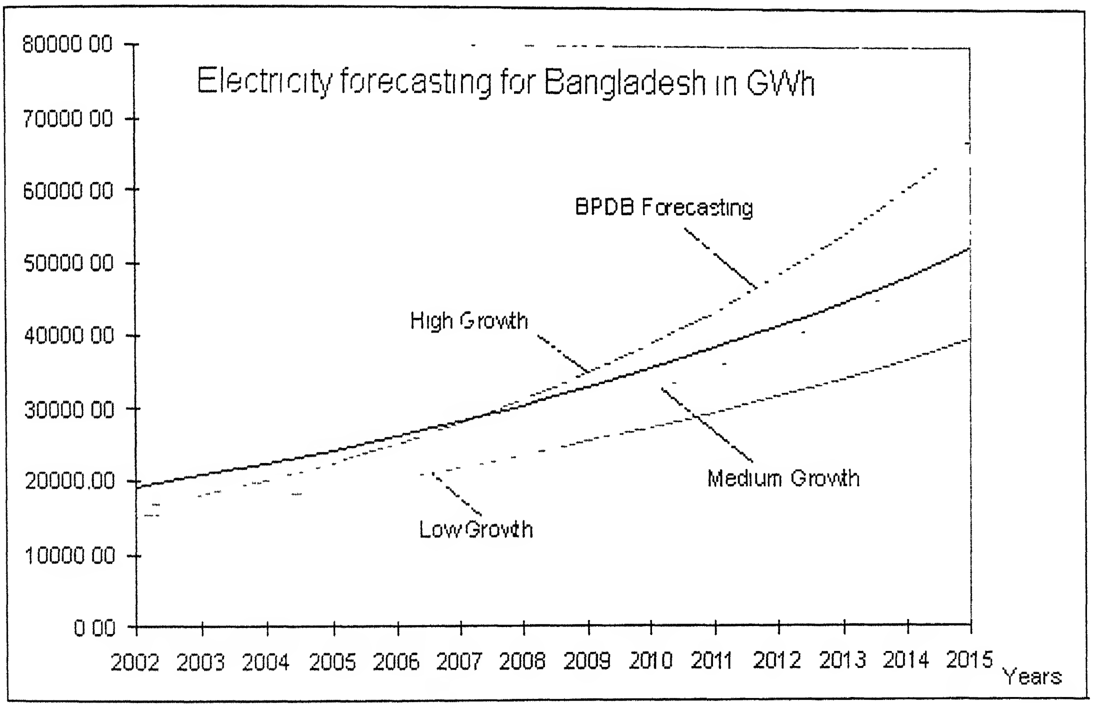
Note : t-statistics in parentheses. ** - 5 percent Significance level *- 10% Significance level

It can be noted that electricity demand in Bangladesh is positively influenced by growth in GDP per capita (constant 1995 LCU). Elasticity of electricity demand to GDP during 1981 to 1998 is 6.70. This means that a 1 percent increase in per capita GDP would result in 6.70 percent increase demand in electricity. As expected, increasing share of the industrial sector in the economy has a positive influence on electricity demand. Again on the other hand, reducing the share of agricultural GDP in economy is

found to have a negative influence on electricity demand. But it is worthwhile to mention that even though share of agricultural activity in the GDP may decline, the energy intensity of agriculture may be increasing.

Now for Bangladesh as mentioned earlier in the table 4.1, we projected all the economic indicators or the independent variables to 2015. This is done for the three different level of growth. GDP per capita (constant 1995 LCU), share of GDP (agriculture), share of GDP(industry) is separately projected. For Bangladesh we do not have sufficient time series data for electricity price. Therefore the one independent variable is dropped for analysis.

Figure 4.7 : Demand forecasting of Bangladesh.



From table 4.5 it is clear that regression model no 2 is much more prospective to forecast the future demand of electricity for Bangladesh. This model is used to forecast the future projection of electrical energy from 2003 to 2015 and presented in table 4.6. According to model 1 we are

using GDP per capita (Constant 1995 LCU), Share of GDP(Agriculture) and time up to 2015. This forecasted electricity demand is compared with the official data source of Bangladesh Power Development Board (BPDB).

Table 4.6 : Electricity Demand Forecasting of Bangladesh

Years	Forecasted Electricity demand (GWh)		
	low	medium	high
2002	14958.22	15479.23	16046.09
2003	16140.8	16991.4	17933.25
2004	17412.72	18646.85	20037.58
2005	18780.64	20458.99	22383.8
2006	20251.74	22442.47	24999.44
2007	21833.68	24613.32	27915.13
2008	23534.73	26989.02	31164.96
2009	25363.74	29588.71	34786.87
2010	27330.22	32433.26	38823.07
2011	29444.39	35545.51	43320.55
2012	31717.19	38950.38	48331.56
2013	34160.40	42675.12	53914.27
2014	36786.65	46749.47	60133.38
2015	39609.48	51205.94	67060.88

Figure 4.7 shows the comparison of our forecasted demand and the forecasting of BDPB data. It shows that initially from 2002 to 2006, BPDB forecasting value is more and after that up to 2015 it is nearer to the medium growth level forecasting.

A model for energy demand as described in section 4.2 is estimated using time series data from 1983 to 2000. The coefficients and the t-statistics are reported below.

Using the best projecting model of independent variables to get the forecasted electricity demand for future. Regression model 1 uses the basic equation with all the independent parameters like GDP per capita (constant 1995 LCU), share of GDP (agriculture), share of GDP(industry) and time. Consequently different model equations are estimated. The values are reported in table 4.7. From this table we will concentrate only the results of regression model 2 as this model gives the expected range and sign of coefficients.

Table 4.7 : Demand equation estimated coefficients of Bhutan

Regression model	Intercept	GDP per capita (constant LCU)	share of GDP (Agri)	share of GDP (Ind)	time	R^2
1	-11.1562 (-0.4055)	0.5733 (1.8067)*	0.0129 (0.0043)	0.2859 (0.1252)	2.0094 (1.5391)	0.929
2	-24.9763 (-0.9559)	3.2502 (1.4587)	0.4994 (0.2091)	-------	0.3568 (1.1973)	0.916
3	-1.5321 (-0.1077)	-0.2280 (-0.1033)	-------	2.0193 (1.6071)	0.5801 (1.9245)*	0.928
4	-25.6068 (-2.641)**	3.5884 (2.883)**	-------	-------	0.2273 (0.7677)	0.920

t-statistics in parentheses. ** - 5 percent Significance level *- 10% Significance level

It can be noted that electricity demand in Bhutan is positively influenced by growth in GDP per capita (constant 1995 LCU). Elasticity of electricity demand to GDP during 1983 to 1990 is 12.20. This means that a 1 percent

increase in per capita GDP would result in 12.20 percent increase demand in electricity. This was very high as during the 6th five year plan(1986-1991) in 1986-87, Chhukha hydro electric plant starts generating electricity[1]. Again elasticity of demand decreases to 2.68 during 1991 to 2000. This can be explained as in 7th and 8th five year plan (1992-2002), only Kurichu (60MW) hydro electric plant and some mini and micro hydel projects totaling 84 MW generation capacity had been added to the existing 344 MW with an increase of 24 percent in the power supply capacity.

As expected, increasing share of the industrial sector in the economy has a positive influence on electricity demand. Again on the other hand, reducing the share of agricultural GDP in economy is found to have a negative influence on electricity demand But it is worthwhile to mention that even though share of agricultural activity in the GDP may decline, the energy intensity of agriculture may be increasing.

Now for Bhutan as mentioned earlier in the table 4.2, we have projected all the independent variables to 2015. This projection is done for the three different level of growth. Calculation of time is started from 1983 as first year and with one increment for each year. Price of electricity is an important economic indicator for the electricity demand forecasting as mentioned above. For Bhutan also we do not have sufficient time series data for electricity price. Therefore the price of electricity is dropped from analysis.

As mentioned earlier regression model no 2 is used to forecast the future projection of electrical energy from 2002 to 2015 and presented in table 4.8. According to model 1 we are using GDP per capita (Constant 1995 LCU), share of GDP(agriculture), share of GDP(industry) and time up to 2015.

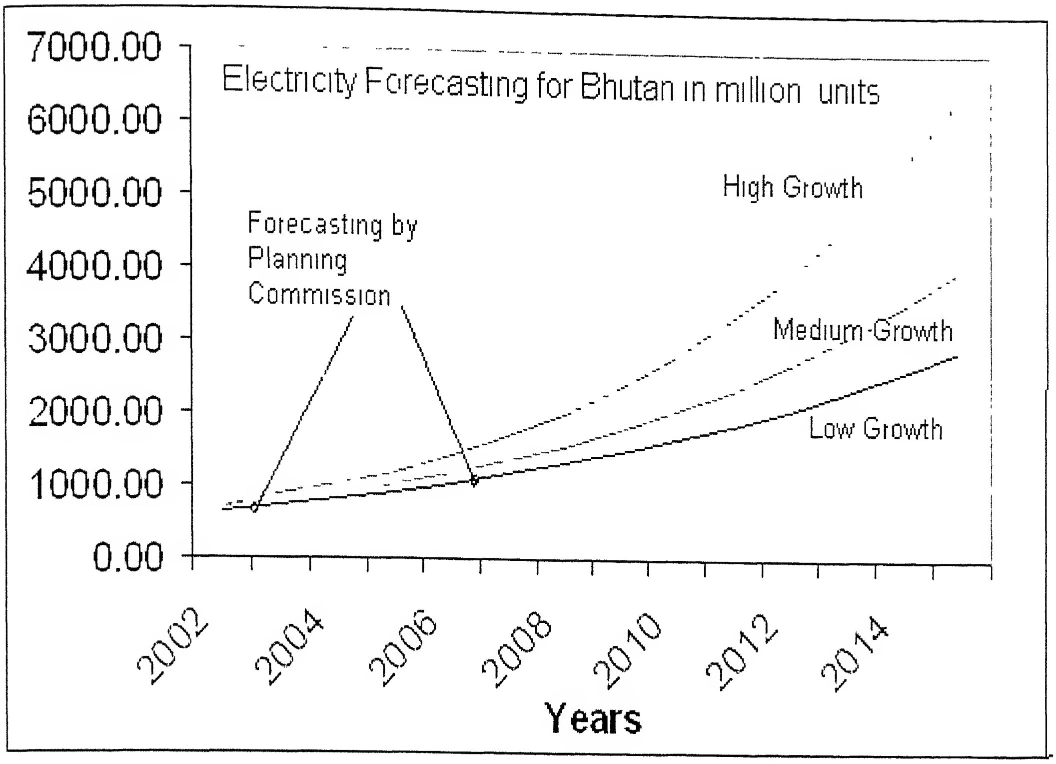
[1] Planning Commission, Royal Government of Bhutan reported in its 6th five year plan report. 1986

Table 4.8 : Electricity Demand Forecasting of Bhutan

Years	Forecasted Electricity demand (Million Units)		
	low	medium	high
2002	573.947	586.563	605.065
2003	648.825	677.663	721.088
2004	732.420	781.788	858.126
2005	825.710	900.740	1019.879
2006	929.780	1036.560	1210.685
2007	1045.831	1191.568	1435.631
2008	1175.195	1368.391	1700.676
2009	1319.350	1570.012	2012.805
2010	1479.930	1799.812	2380.199
2011	1658.749	2061.625	2812.438
2012	1857.815	2359.795	3320.741
2013	2079.352	2699.247	3918.237
2014	2325.823	3085.562	4620.294
2015	2599.958	3525.061	5444.893

Official electricity demand projection for Bhutan is not available. But, in the Ninth five year plan (2002-2007) of Royal Government of Bhutan in the chapter 22 has mentioned that the annual electricity consumption is growing at an average rate of 9.53 percent and national demand has grown 532 million units in 2000 from 338 Million units in 1995. According to this information the electricity need for Bhutan in 2003 will be 699.05 million units and in 2007 it will be 1006.105 million units. This can be compared with our analysis in table 4.8 with the low growth column.

Figure 4.8 : Demand forecasting for Bhutan.



4.5.3 India

A model for energy demand as described in section 4.2 is estimated using time series data from 1971 to 2000. The coefficients and the t-statistics are reported below in table 4.9.

We have estimated taking different sets of equations with different combinations of independent variables to get the optimum and best forecast for future projections. Regression model 2 uses the basic equation with all the independent parameters like GDP per capita (constant 1995 LCU), share of GDP (agriculture), share of GDP(industry), WPI (power, fuel, electricity and lubricant), WPI (all commodities) and time. Consequently different model equations are tried. The $\bar{R}^2$ values are reported in table 4.9. From this table we will concentrate only the results

of regression model 2 only as this model gives the expected range and sign of coefficients

Table 4.9 : Demand equation estimated coefficients of India.

Reg model	Intercept	GDP per capita (constant LCU)	share of GDP (Agri)	share of GDP (Ind)	WPI (Power)	WPI(Power) /WPI(All)	time	R^2
1	-8.391 (-1.772)*	1.481 (4.892)**	-0.358 (-0.785)	0.465 (0.906)	-0.018 (-0.120)		0.065 (0.934)	0.986
2	-6.893 (-1.577)	1.362 (6.624)**	-0.629 (-1.323)	0.586 (1.204)		-0.308 (-1.364)	0.078 (1.614)	0.987
3	-7.703 (-4.047)**	1.373 (5.552)**	-------	-------	0.115 (0.904)	-------	0.075 (1.070)	0.984
4	-9.250 (-11.86)**	1.579 (17.413)**	-------	-------	-------	0.035 (0.185)	0.126 (2.912)**	0.984
5	-1.862 (-1.812)*	1.320 (5.101)**	-0.572 (-1.472)	-------	0.019 (0.136)	-------	0.078 (1.150)	0.985
6	-11.275 (-3.806)**	1.577 (5.740)**	-------	0.674 (1.547)	0.010 (0.070)	-------	0.058 (0.839)	0.985

t-statistics in parentheses. ** - 5 percent Significance level *- 10% Significance level

It can be noted that electricity demand in India is positively influenced by growth in GDP per capita (constant 1995 LCU). The average elasticity of electricity demand to GDP during 1981 to 1998 is 2.154 and from 1991 to 1998 is 1.162. This means that a 1 percent increase in per capita GDP would result in 1.162 percent increase demand in electricity from 1991 to 1998. As expected, increasing share of the industrial sector in the economy has a positive influence on electricity demand. Again on the other hand, reducing the share of agricultural GDP in economy is found to have a negative influence on electricity demand. But it is worthwhile to mention that even though share of agricultural activity in the GDP may decline, the energy intensity of agriculture may be increasing.

Now for India as mentioned earlier in the table 4.4, we projected the growth of all the economic indicators or the independent variables to 2015.

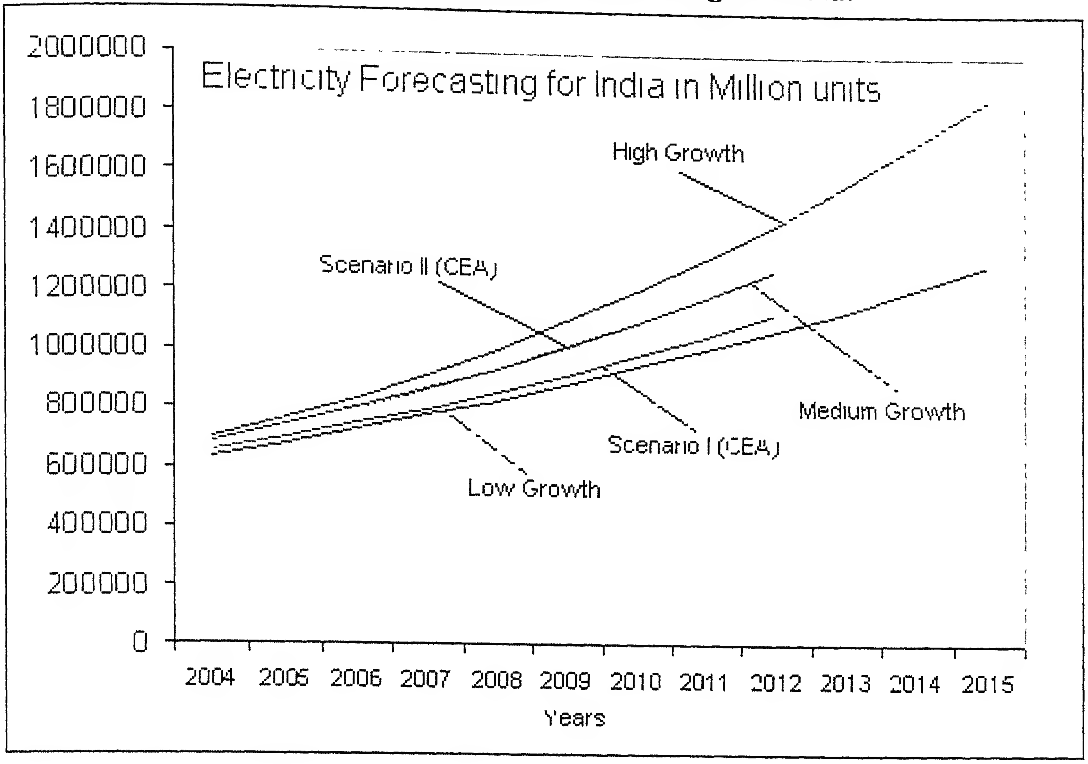
This is done for the three different level of growth. GDP per capita (constant 1995 LCU), share of GDP (agriculture), share of GDP(industry) is separately projected. In this analysis we have used WPI (power, fuel, electricity and lubricant) and WPI (all commodities) as independent variable. In regression model 1 we have used WPI (power, fuel, electricity and lubricant) as the independent variable and in regression model 2 we have used WPI (all commodities). From this analysis regression model 2 gave us the expected range and sign of coefficients of the b_i values.

The regression model 2 is used to forecast the future projection of electrical energy from 2003 to 2015 and presented in table 4.10.

Table 4.10 : Electricity demand forecast of India.

Years	Forecasted Electricity Demand in million kWh		
	low	medium	high
2004	628643.8	680017	744833.9
2005	672100.9	742525	832023.7
2006	748516.4	810727.2	929360.6
2007	768091.2	885140.6	1038022
2008	821039.6	966329	1159323
2009	877590.6	1054907	1294728
2010	937988.5	1151546	1445874
2011	1002494	1256977	1614586
2012	1071387	1371996	1802901
2013	1144962	1497474	2013091
2014	1223539	1634359	2247690
2015	1307456	1783685	2509528

Figure 4.9 : Demand Forecasting of India.



From the above figure 4.9 it is clear that the forecasting of Central Electricity Authority (CEA, 2000)[2] is comparable with our forecasting. CEA used two scenario of growth for forecasting of the electricity demand. For scenario I CEA used 6.5 percent growth of electricity demand whereas in scenario II used 7.1 percent. Scenario-II is same with our medium growth model. It is also evident from figure 4.9 that the official forecasting (CEA, 2000) is much more nearer to our forecasting and scenario-I lies between the low and medium growth level of electricity consumption.

4.5.4 Nepal

A model for energy demand as described in section 4.2 is estimated using time series data from 1971 to 2000. The coefficients and the t-statistics are reported below.

[2] Central Electricity Authority (CEA), Ministry of Power, Govt of India, New Delhi in its 16th Electric Power Supply of India has projected the expected demand in two different growth level

It could be noted that coefficient of share of DGP (Agri) and GDP(Ind) are not significant and hence do not seem to have justifiable influence in electricity demand in Nepal. It would also be noted that in terms of significance of estimated coefficients model 2 gives the best results. The estimated coefficient of GDP and time trend are significant at 5 percent significance level. Hence, we would utilize model 2 for electricity demand forecast in case of Nepal.

It can be noted that electricity demand in Nepal is positively influenced by growth in GDP per capita (constant 1995 LCU). Elasticity of electricity demand to GDP during 1983 to 1998 is 6.58 and from 1991 to 1998 is 2.25. This means that a 1 percent increase in per capita GDP would result in 2.25 percent increase demand in electricity during 1991 to 1998. Interestingly, elasticity value was greater during 80's and decreases in 90's. This is very much significant in this case for Nepal. This can be illustrated that during this period the GDP growth is more than the electricity consumption growth and no major electricity projects are taken up for operation during this period[3]. Again elasticity of electricity consumption to GDP in the model 2 is 2.62 as expected. Again model 2 gives us better significance level of t-statistics than the model 1.

[3] In the managing Director's Report (2000-2001), Nepal Electricity Authority (NEA) it was stated that after the millennium years only, Nepal drives for the privately owned mini and micro hydel plants and before this period Nepal's national grid was in deficiency in the form of load shedding over the past decade.

Table 4.11 : Demand equation estimated coefficients of Nepal

Regression model	Intercept	GDP per capita (constant LCU)	share of GDP (Agri)	share of GDP (Ind)	time	R^2
1	-3.3108 (-0.3763)	0.7492 (1.2499)	-0.6015 (-0.5900)	0.7314 (1.3619)	0.2866 (4.8128)**	0.9736
2	-19.0181 (-7.3299)**	2.6184 (7.7543)**	------	------	0.4260 (8.0462)**	0.9567
3	4.6210 (0.6888)	0.5940 (0.9926)	-1.8105 (-3.551)**	------	0.3244 (6.0557)**	0.9716
4	-8.1249 (-2.4988)**	0.9604 (2.0246)*	------	1.0073 (3.8658)**	0.2811 (4.8429)**	0.9733

Note : stics in parentheses. ** - 5 percent Significance level *- 10% Significance level

Now for Nepal as mentioned earlier in the table 4.4 and 4.11, we have projected all the independent variables to 2015. This projection is done for the three different level of growth. Calculation of time is started from 1971 as first year and with one increment for each year. Price of electricity is an important economic indicator for the electricity demand forecasting as mentioned above. For Nepal also we do not have sufficient time series data for electricity price. Therefore the price of electricity is dropped from analysis. As mentioned earlier regression model no 2 is used to forecast the future projection of electrical energy from 2002 to 2015 and presented in table 4.12. According to model 2 we are using GDP per capita (Constant 1995 LCU) and time up to 2015.

Nepal Electricity Authority (NEA) has forecasted the demand projection[4] up to 2015 and beyond. This forecasting can be easily compared with the high growth column (see figure 4.10). Nepal's electricity consumption is increasing rapidly with a average growth rate of 8 percent per annum. This NEA report also says that in the 2006-07 and 2007-08, the

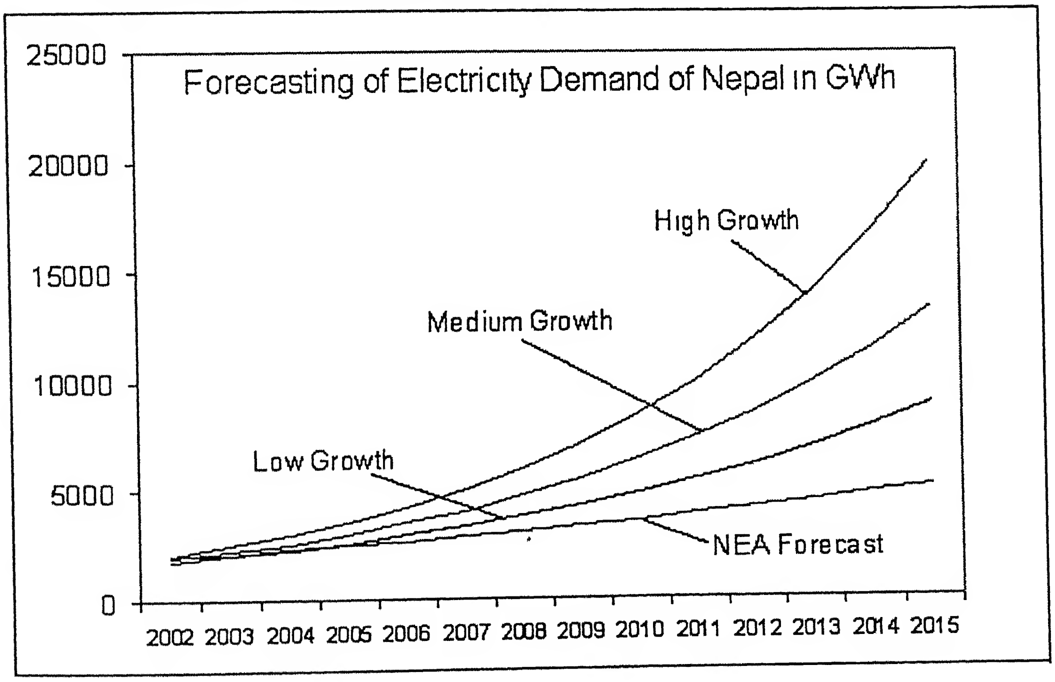
[4] The Load forecasting according to the Power System Master Plan (PSMP) studies undertaken by Nepal Electricity Authority (NEA) and completed in 1998 under Chapter 4 : Electricity Demand Forecast (Load Forecast), NEA: Corporate Development Plan, Kathmandu, Nepal.

electricity demand growth was considered as 8.7 and 8.5 percent respectively.

Table 4.12 : Electricity Demand Forecasting of Nepal

Years	Forecasted electricity demand (GWh)		
	low	medium	high
2002	1796.43	1937.37	2087.86
2003	2038.55	2254.54	2491.02
2004	2311.95	2622.10	2970.29
2005	2620.52	3047.84	3539.74
2006	2968.59	3540.70	4215.98
2007	3361.02	4110.97	5018.62
2008	3803.33	4770.57	5970.91
2009	4301.68	5533.23	7100.34
2010	4863.01	6414.76	8439.38
2011	5494.97	7433.18	10026.16
2012	6206.05	8609.12	11905.52
2013	7005.75	9966.27	14130.33
2014	7904.65	11531.72	16762.70
2015	8914.44	13336.45	19875.59

Figure 4.10 : Electricity Demand forecasting of Nepal in GWh



4.6 Electricity Supply Position by 2006-07

4.6.1 Bangladesh

Bangladesh had an installed power generating capacity of 3770 MW in 2000. In January, 2003 Bangladesh has the total generation capacity of 3407 MW (considering 20 percent loss). But the actual power output is very much less than the installed capacity. In the year 2000 Bangladesh has consumed approximately 11,000GWh. According to BPDB, this consumption of electricity is increasing with a growth rate of 6-7 percent. In 2002, electricity consumption was about 19232 GWh[5]. Bangladesh Power Development board also forecasted the peak demand in the year 2002 as 3659MW. According to BPDB data Bangladesh has served 3171MW as peak demand in 2002. This peak demand increases 7-8 percent annually.

It is to be noted here that Bangladesh needed an additional capacity addition of 400MW to 500MW per annum by the year 2004 to meet its required peak demand of 4259MW. In table 4.13, the upcoming electricity plants for Bangladesh are shown.

BPDB has projected the power demand for 2002 as 3659 MW and deficit was 252 MW with an existing capacity of 3407 MW. Similarly, in 2003, 2004 and 2005 deficit will be 90 MW, 152 MW and 290 MW respectively. But in 2006 and 2007 the electricity demand will be surplus after completion of the new planned projects successfully.

[5] Source note: According to Power System Master Plan (PSMP) of Bangladesh Power Development Board (BPDB) of 1995 benchmark load forecast was based on about 8 percent growth rate.

Table 4.13: Upcoming power plants in Bangladesh.

Sl No.	Generation Station	Capacity (MW)	Expected commissioning date
1	Meghnaghat 450MW Gas based	450	Oct, 2002
Total			450 MW
2	Siddhirganj Thermal power station, Gas	210	June, 2003
3	Baghbari Combined Cycle(CC), Gas	40	2003
Total			250 MW
4	Tongi Gas turbine power station	80	2004
5	Siddhirganj 120MW Gas turbine PS	120	2004
Total			200 MW
6	109 CC addition to Haripur GTPS	109	2005
7	Chandpur 150MW CC Power Plant	150	2005
8	Sylhet 150MW CC Power Plant	150	2005
9	Barapukhuria 300MW coal based PP	300	2005
10	Gazipur Gas turbine Power Plant	40	2005
11	Fenchuganj 90 MW CCPP	90	2005
12	Serajganj CC Power Plant	450	June, 2005
Total			1289 MW
13	Khulna Thermal Power Station	210	2006
14	Bhola 150MW CCPP	150	2006
15	Meghnaghat 450MW CC (Unit II)	450	June, 2006
Total			810 MW
16	Kaptai Power plant extension	100	2007
17	Siddhirganj Thermal PS (Unit II)	210	2007
18	Bheramara CCPP	450	June, 2007
19	East Zone gas turbine	150	2007
20	Sikalbha Thermal Power Station	60	2007
21	Khulna Peaking power plant	100	2007
Total			1070 MW
Grand Total			3069 MW

Source : Bangladesh Power Development Board.

The Bangladesh Power Development Board has projected peak demand for Bangladesh to be about 6,000 MW by 2007, based on the effect of certain power sector reforms, such as higher tariffs and lower losses. To supply this demand, approximately 2,400 MW of capacity additions are required from the end of 1998 through 2007. Some of this capacity is

under construction (e.g., 420 MW at Ghorasal and Siddirganj, 120 MW of combustion turbines at Mymensing and Shajibaza, and an additional 100 MW from combustion turbine conversion to combined cycle at Haripur). Additional capacity is being phased in by IPPs, such as the 360 MW project at Haripur and the 450 MW project at Meghnaghat. However, most of this generation is located east of the Jamuna River. The only projects west of Jamuna are the rehabilitation of the Khulna 100 MW steam plant and a 100 MW gas-fired plant at Baghabari, which is still under negotiation.

In November 2000, the United States and Bangladesh signed an agreement for cooperation on the peaceful use of nuclear power. Under the agreement, Bangladesh is to receive technical assistance for its planned Rooppur nuclear plant. Bangladesh is a signatory to the Nuclear Non-Proliferation Treaty, and ratified the Comprehensive Test Ban Treaty in March 2000.

The Padma-Jamuna-Meghna river system divides Bangladesh into two zones, East and West. The East contains nearly all of the country's electric generating capacity, while the West, with almost no natural resources, must import power from the East. Electricity interconnection from the East to the West was accomplished in 1982 by a 230kV power line. The vast majority of Bangladesh's electricity consumption takes place in the East, with the entire region west of the Jamuna River accounting for only 22% of the total. Greater Dhaka alone consumes around half of Bangladesh electricity.

4.6.2 Bhutan

During the Eighth five year plan (1997-2002) Plan, Royal Government of Bhutan, 82.4 MW and 506 million units of hydropower has been added to the existing capacity, bringing the total installed capacity of the power system as a whole to 444 MW, including diesel generating capacity of 3.57 MW installed in various Dzongkhag (District) headquarters. This represents a 24 percent increase in the total installed capacity during 1996 - 2001. Annual average energy generation capacity has also been enhanced to 2,326 million units from 1,838 million units at the end of the Seventh Plan.

The commissioning of 60 MW Kurichhu Hydroelectric Project, Basochhu Upper stage of 22.2 MW and Rongchhu micro hydel of 200 kW were the main sources of additional power generation. Moreover, Tala Hydroelectric Project (1,020 MW) and Basochhu Lower Stage (40 MW) are under construction and expected to be completed by the year 2005.

Bhutan expected 9.3 percent growth of electricity during the Ninth Plan (2002-2007)[6]. In 1997, at the start of the Eighth Plan, Bhutan exported 1,354 million units of electricity to India and imported 32 million units of electricity. By 2000, export has shot up to 1,495 million units. With regard to harnessing of the vast hydropower potential, feasibility studies were completed for Mangdechhu Hydroelectric Power Plant (360 MW) and Punatsangchhu Hydroelectric Power Plant (870 MW). These two plants are techno-economically feasible and they will be undertaken in the Ninth Plan. In addition, four feasible micro-hydel sites have been identified at Sengor, Sakten, Tang and Gasa.

[6] This is referred from the Ninth Five Year Plan Report, Planning Commission, Royal Government of Bhutan

According to Planning Commission report, 2002, the gross energy generation from power utilities at the beginning of the Ninth Plan (1997) was 394 5 billion kWh. In 2002, the actual energy generation has been 515.3 BU. This works out to a compound annual growth rate (CAGR) of about 5.5 percent during the Ninth Plan period (Five years).

Table 4.14: Addition to Installation capacity (in MW) during 1997-2002

Type	Central Sector	State Sector	Private Sector	Total
Hydro	540	3912	86	4538
Thermal	3084	5538	4975	13597
Nuclear	880	-----	-----	880
Total	4504	9450	5061	19015

Source: India, 2002(b).

The all-India installed generating capacity of utilities at the beginning of the Ninth Plan was 84,893 MW (excluding wind capacity of 902 MW). This included 21568 MW of hydro, 61012 MW of thermal and 2225 MW of nuclear power. The Ninth Plan programme envisaged a capacity addition of 40,245 MW. As against this, the actual capacity addition was 19015 MW during the Ninth Plan (Refer table 4.14). Again during 1992-97 capacity addition was 16422 MW. The sector-wise shortfalls during the Ninth Plan were :central sector 62.2 percent, state sector 12.1 percent and private sector 71.2 percent. The achievement of 19015 MW represents an addition of 3803 MW per annum, compared to the target of 8049 MW per annum (India, 2002(b)). The main reasons for the shortfall in capacity addition are: inability to get private sector projects off the ground in the absence of adequate arrangements for ensuring payment security, delay in land acquisition and environmental clearances, unresolved issues relating to fuel linkages, contractual problems, resettlement and rehabilitation problems and law and order problems.

The cumulative capacity at the end of the Ninth Plan in March 2002 was 104917.50 MW, including 1507.5 MW wind energy. This is reported in table 4.15.

Table 4.15: All India capacity addition.

Sector	Hydro	Thermal	Nuclear	Total
Central	3049.00	25836.51	2720.00	31605.51
State/ UTs	22636.02	39546.59	0.00	62182.61
Private	576.20	9045.72	0.00	9621.92
Total#	26261.22	74428.82	2720.00	103410.04

Source: India, 2002(b). Note : # Excludes of 1507.46 MW from wind.

In 1997 it was estimated by the Planning Commission that the energy and peak deficits were 11.5 percent and 18 percent respectively. But at the end of 9th plan in 2002, energy and peak deficit was 7.5 percent and 12.6 percent respectively.

According to the Sixteenth Electric Power Survey (EPS), the total electricity requirement for India in different regions in 2006-07 will be as follows (Table-4.16).

Table 4.16 Demand of Power in 2006-07.

Region	Energy Requirement in GWh		Peak Load in MW	
	2006-07	2011-12	2006-07	2011-12
Northern	220820	308528	35540	49674
Western	224927	299075	35223	46825
Southern	194102	262718	31017	42061
Eastern	69467	90396	11990	15664
North-Eastern	9501	14061	1875	2789
Anda & Nicobar Isl	236	374	49	77
Lakshadweep	44	70	11	17
All India	719097	975222	115705	157107

Source : Sixteenth EPS, 2000.

India, 2002(b) also has envisaged a capacity addition requirement of 46,939 MW during 2002-07, with 24,405 MW coming from the central sector, 12,033 MW from the state sector and 10,501 MW from the private sector. However, keeping in view the status of the ongoing, sanctioned

and new projects in the pipeline, the Planning Commission felt that a target capacity addition of 41,110 MW with 18,659 MW from ongoing projects, 9,193 MW from projects cleared by the CEA and 13,258 MW from new schemes. Out of the total addition of 41,110 MW envisaged for the Tenth Plan period, 22,832 MW (55.6 percent) is accounted for by the central sector and 11,157 MW (27.1 percent) is accounted for by the state sector. The balance of 7,121 MW (17.3 percent) is expected to be added by the private sector. The cumulative generation capacity in the country by the end of 2006-07 is reported in table 4.17.

Table 4.17Generating Capacity anticipated by 2006-07

Capacity Addition	Hydro	Thermal	Nuclear	Total
Capacity as on 31.03.2002	26261.22	74428.82	2720.00	103410.04
Addition during 2002-03 to 2006-07	14393.20	25416.64	1300.00	41109.84
Total capacity on 31.03.2007	40654.42	99845.46	4020.00	144519.88

Source : India, 2002(b)

The energy and peaking shortages at the end of the Ninth (March, 2002) Plan are 7.5 percent and 12.6 percent respectively. It is also estimated that if capacity addition targets are met, the energy and peaking shortages would be 11.6 percent and 9.5 percent respectively by the end of the Tenth Plan(India, 2002(b).

4.6.4 Nepal

In the year 1999 - 2000 Nepal had the hydroelectricity generation of 323.2 MW, this is the 0.4 percent of the total hydro potential. In 2000-01 this generation of hydro power increased to 373.2 MW. Another two hydro electric plant Kali Gandaki -1 (144MW) and Indrawati stage III (7.5MW) has been added in 2001-02 to the system with a total

MW. Exixting hydro power plants are shown in table 4.18.

Table 4.18: upcoming power plants in Nepal

MAJOR HYDRO PROJECT (MW)	
Existing Installed capacity	
1. Trisuli	24
2. Sunkosi	10.05
3. Gandak	15
4. Kulekhani No.1	60
5. Devighat	14.1
6. Kulekhani No.2	32
7. Marsyangdi	675
8. Puwa Khola	6.2
9. Modi Khola	14.8
	Total 851.15 MW

Source: NEA, 2001b

To meet the forecasted demand of electricity Nepal has to increase its production of electricity with an average of 10 percent growth. Nepal Electricity Authority forecasted that by 2004 another 93 MW will be added to the exiting system with the expansion of Marsangdi stage II (70MW), Chilime Khola (20 MW) and Piluuwa Khola (3 MW). Another interesting fact mentioned in the annual report of the NEA is that in 2001, Nepal imported 1868.4 GWh from India and in 2002 it increased to 2372.9 GWh. On the other hand, in 2001, Nepal exported 126GWh energy to India and in 2002, exported 170 GWh. But in spite of this energy transfer from India and capacity expansion in2002, Nepal still had 730.4GWh of energy deficit in internal consumption. In the table 4.19 some upcoming hydro projects are reported. Some of these projects are under construction and some are in geological survey and dam construction stage. These proposed hydro electric plants are expected to completed by 2006-07 to 2015-16. According to NEA demand forecasting by 2007 Nepal will need 679 MW of peak demand. Middle Marsyangdi and Kulekhani-3 have been proposed for implementation by

NEA in order to meet the power shortage from the year 2004-05. and this will certainly meet after completing the Kaligandaki-A project by the year 2003. After completing these projects Nepal will have surplus electricity by 2007.

Table 4.19: upcoming power plants in Nepal

Projects	Installed Capacity (MW)	Average Annual Energy (GWh)	Commissioning Year
Middle Marsyangdi	70	393	2004-05
Chameliya	30	195	2004-05
Kulekhani Stage III	42	49	2005-06
Nyadi	20	127	2005-06
Rahughat	27	165	2006-07
Abeli Stage A	30	164	2006-07
Likhu stage 4	44	271	2006-07
Thulo Dhunga	24.7	202	2006-07
Upper Marsyangdi - 3	70	409	2006-07
Khimti stage 2	27	157	2006-07
Budhi Ganga	20	106	2006-07
Tamur Mewa	101	489	2006-07
Upper Modi A	42	285	2006-07
Lower Modi	19	123	2006-07
Andhi Khola	176	547	2007-08
Upper Karnali	300	2133	2008-09
Arun 3	402	3046	2009-10
Lower Arun	308	2427	2009-10
Tamakoshi 3	330	1702	2009-10
Dudh koshi 1	300	1702	2009-10
Upper Arun	335	2734	2010-11
Kali Gandaki 2	660	2910	2010-11

Source: NEA, 2001b.

Nepal and India is having two Power transmission line of 132kV. At present the power exchange capacity with India is 50 MW (NEA, 2001(b). According to the Managing Director's report of NEA (2000-01), negotiations are ongoing with India to increase this transmission capacity to 150 MW, for this two 132 kV transmission lines have been agreed upon. The Butwal (Nepal) - Anandanagar (India) transmission line is

expected to be completed in July 2004 and the Parwanipur (N) – Motihari (I) and Dhalkebar (N) – Sitamadhi (I) two lines by July 2006. Once the Butwal – Anandanagar transmission line comes into service, the exchange capacity will increase to 100 MW and when the other two lines are commissioned in July 2006, then the power exchange capacity will increase to 150 MW or more.

4.7 Assessment of Demand and Supply mismatch and Trading Potential in 2006-07

In section 4.5 and 4.6 we have discussed the demand up to 2015 and the supply position of the SAGQ countries respectively. Various government and nodal organizations forecasted the demand scenario of these countries in the SAGQ region. In this section we will present the supply and demand situation for the year 2006-07 for these countries in this region. In the available energy calculation the power plant is expected to be in operation for 300 days in a year. It is also pointed out here that in our future demand projection for the countries in SAGQ we have considered three different level of economic growth and in this section all these three different electricity demand projection is used to calculate the electricity demand snapshot for the year 2006-07.

4.7.1 Bangladesh Scenario

In the previous section 4.5.1 it is discussed that Bangladesh have three different electricity demand pattern for the year 2006 [7] according to different economic growth levels. Considering the Plant Load factor (PLF) [8] and Transmission and Distribution (T&D) losses to be average 60

[7] All the demand and supply for Bangladesh is calculated taking the calendar year and Bangladesh Power Development Board also uses the calendar year for all its demand and supply situation forecasting.

[8] Bangladesh Power Development Board also calculates its energy taking average 60 percent of Plant Load factor (PLF) for its daily forecasting demand.

percent and 30 percent respectively, the demand from these three scenarios are also reported below.

Total generation capacity up to January, 2003 was 3407 MW. As shown in table 4.13, the total installed capacity is expected to be 2549 MW. Taking PLF as 60 percent, the available capacity is expected to be 1529.4 MW. The total available demand up to 2006 including the existing capacity and the expected capacity during this period is expected to be will be 3573.6 MW. Taking the transmission & distribution (T&D) and other system loss as 45 percent, total available energy in the year 2006 is expected to be 16981.75 GWh. The requirement, availability and shortage of electricity demand is reported in table 4.20.

Table 4.20 Supply and Demand Scenario of Bangladesh in 2006.

	Availability	Requirement			Shortage		
		Low Growth	Medium Growth	High Growth	Low Growth	Medium Growth	High Growth
Capacity Available (MW)	3573.60	4261.73	4722.74	5260.82	688.13	1149.14	1687.22
Energy (GWh)	16981.75	20251.74	22442.47	24999.44	3269.99	5460.72	8017.69

From figure 4.7 it is evident that our analysis and BPDB forecasting lcrosses over the high economic growth and then touches the medium growth level. Therefore, the expected energy demand for Bangladesh in 2006 will lie between medium and high economic growth scenario. The deficit of electrical energy in the near future invites the notion of electricity trading.

4.7.2 Bhutan Scenario

In 2002 Bhutan had the generation capacity of 444 MW and during the Ninth Five year plan (up to 2006-07) Tala hydro electric plant (1020 MW) and Basochhu Lower stage (40 MW) are expected to be commissioned with a total of 1060 MW capacity addition with the existing capacity. It is assumed that the PLF of the power plant in Bhutan to be 70 percent and the available capacity is expected to be 742 MW. The total generation capacity considering the PLF including the existing and upcoming power plants in 2006-07 is expected to be 1186 MW. T&D loss and other system loss is assumed to be 45 percent and the available energy in 2006-07 is expected to be 5635.87 GWh. The requirement, availability and shortage of electricity demand snapshot in 2006-07 is reported in table 4.21. Bhutan uses the financial year and in demand forecasting we are using calendar year and in the calculation of shortage of electrical energy and demand there is difference of three months and are neglected in this calculation as this should not effect our projection significantly.

Table: 4.21 Supply and Demand Scenario of Bhutan in 2006-07.

	Availability	Requirement			Shortage		
		Low Growth	Medium Growth	High Growth	Low Growth	Medium Growth	High Growth
Capacity Available (MW)	1186.00	195.66	218.13	254.77	-990.34	-967.87	-931.23
Energy (GWh)	5635.87	929.78	1036.56	1210.69	-4706.09	-4599.31	-4425.19

Bhutan will have surplus of electricity beyond its domestic consumption. This surplus electrical energy in Bhutan advocates electricity trading between the neighboring countries. The existing energy trade between Bhutan and other countries in this region is discussed in the next chapter.

4.7.3 Indian Scenario

Central Electricity Authority (CEA, 2000) and the Planning Commission report on State Electricity Board and Electricity Department (India, 2002b) reveals that the total generating capacity of India by 31.03.2007 is expected to be 144519.88 MW (Refer table 4.17). In 2000 PLF was 69 percent and in 2001 PLF was 69.9 percent (India, 2002a). Again in 2000-01 and in 2001-02 the T&D losses were 29.9 percent and 27.8 percent respectively (India, 2002a). According to the current scenario assuming T&D loss in 2006-07 is expected to be 29 percent in the calculation of electric energy in this section. For India also the demand forecasting was done on the basis of calendar year but the official sources expressed the capacity availability in the basis of financial year. The effect of three months is neglected in our calculation. The available energy in 2006-07 is expected to be 646857 GWh[9] (CEA, 2000). The requirement, availability and shortage of electricity in 2006-07 is reported in table 4.22.

Table: 4.22 Supply and Demand Scenario of India in 2006-07.

	Availability	Requirement			Shortage		
		Low Growth	Medium Growth	High Growth	Low Growth	Medium Growth	High Growth
Capacity Available (MW)	144519.88	140554.85	158592.96	181799.80	39390.93	57429.04	80635.88
Energy (GWh)	739219.18	718516.4	810727.2	929360.6	71659.4	163870.20	282503.60

In 2006-07, India will face a serious shortage of power and this also advocates the need of power trading from the neighbouring countries like Bhutan.

[9] This figure is taken for the year 2006-07.

4.7.4 Nepal Scenario

In 2001-02, the existing electricity generation capacity of Nepal was 524.9 MW (refer section 4.6.4). Again referring to table 4.19, the installed capacity in 2006-07 is expected to be 512.7 MW and energy available is expected to be 3153 GWh. The PLF of Nepal electricity is approximately 70 percent as stated by the Nepal Electricity Authority The additional generating capacity in 2006-07 will be 358.89 MW Nepal Electricity Authority also uses financial year to calculate the electricity demand. In section 4.5.4 the future electricity demand is calculated for Nepal using calendar year and the effect of three months are assumed to be neglected. The available energy in 2001-02 was 2078.60 GWh assuming 45 percent T&D loss. The total available energy in 2006-07 is expected to be 5231.60 GWh. The expected generating capacity in 2006-07 is 883.79 MW. The shortage, requirement and the available energy and demand is reported in table 4.23.

Table 4.23 Supply and Demand Scenario of Nepal in 2006-07.

	Availability	Requirement			Shortage		
		Low Growth	Medium Growth	High Growth	Low Growth	Medium Growth	High Growth
Capacity Available (MW)	883.79	624.70	745.10	887.20	-259.09	-138.69	3.41
Energy (GWh)	5231.60	2968.59	3540.70	4215.98	-2263.01	-1690.90	-1015.62

Nepal will have surplus of electricity by 2006-07. This surplus electricity supports the electricity trading between the neighboring countries. The interesting point to be noted here is that considering high economic growth Nepal will have shortage of electricity in 2006-07.

In 2006-07 the South Asia region as a whole will be energy deficit as depicted in the figure 4.11. Energy and capacity demand shortage in 2006-07 using the three different growth levels are reported in table 4.24. In the next chapter we will discuss the present scenario of electricity trading and other elated issues and benefits of power trading.

4.24: Gross Shortage of Energy and capacity of SAGQ in 2006-07

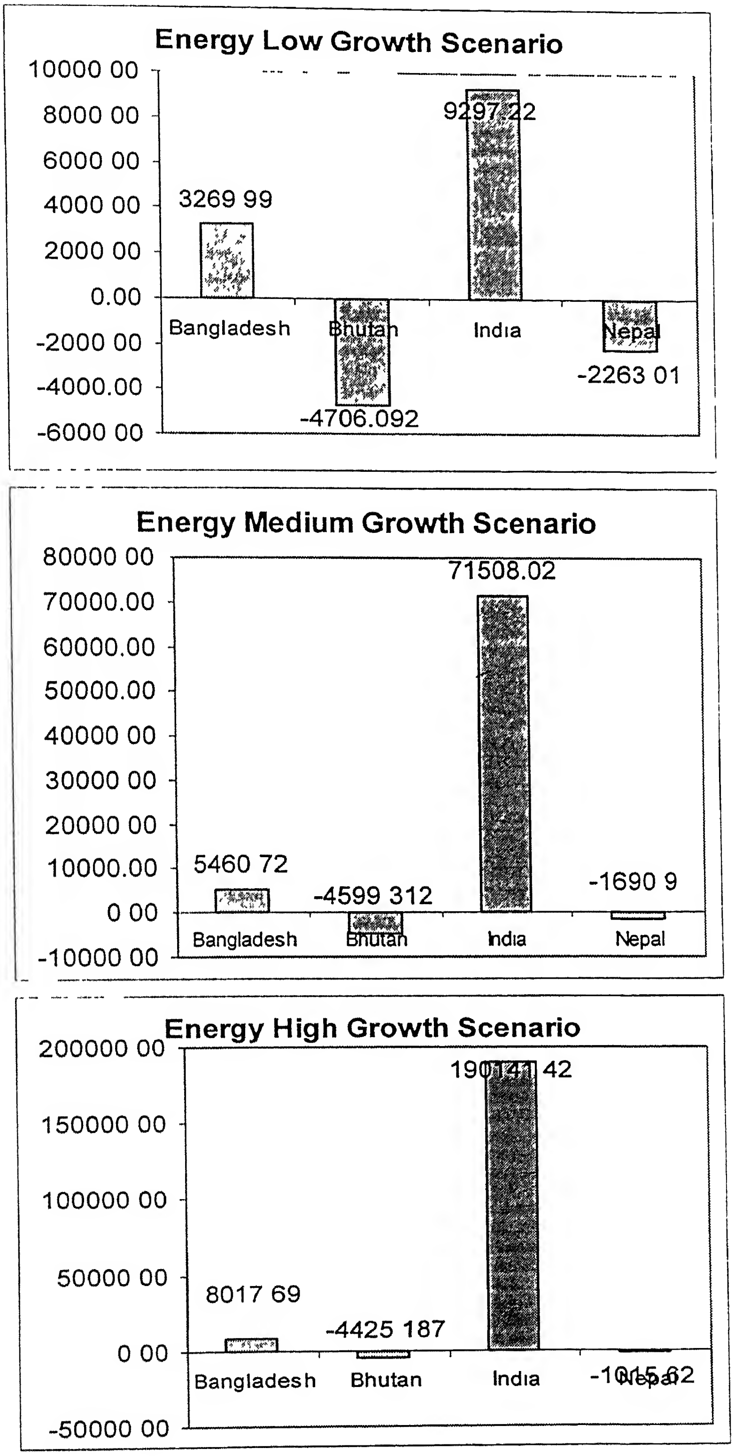
Region	Low Growth	Medium Growth	High Growth
Capacity (MW)	1342.22	14115.66	38039.33
Energy (GWh)	5598.111	70678.53	192718.3

The projected demand and supply situation in the four countries of SAGQ region reveals that as per planned capacity addition, the capacity available for trading would be limited and fall short of that of expected energy. Also, in the short to medium run, the existing bilateral arrangement would drive electricity trade across the borders. However, there are larger potential for electricity trade due to huge capacity shortage in India.

Again, from the above figure4.11, it can be noted that in low growth scenario Bhutan and Nepal have surplus of electrical energy of 4706. 09 GWh and 2263.01 GWh respectively with a total of 6969.10 GWh. Similarly, for medium and high growth scenario the surplus electricity in 2006-07 in this two country will be 6290.211 GWh and 5443.207 GWh respectively. Again on the other hand India and Bangladesh will have deficit of electricity by 2006-07. Considering the present demand and supply mismatch among the countries of the region, the two surplus countries, namely Bhutan and Nepal can trade electrical energy to the extent of 6290.21 GWh with the deficit countries i.e. Bangladesh and India. Even after such a trading scenario the region will face a large deficit of 70678.53 GWh which signifies significant electrical trading in

the region if more economically exploitable resources can be harnessed through enhanced investment in the power sector in the region

Figure 4.11 : Energy Shortage Scenario in SAGQ in 2006-07



This would not only result in revenues due to electricity trade but also higher availability of electricity for consumers especially in case of Bhutan and Nepal, where electricity connectivity is low.

Chapter 5

Cross Border Power Trading Principles and Experiences

5.0 Introduction

Demand for energy including electricity has been increasing more rapidly in developing South Asian economies. In order to meet the rapidly increasing power demand in these countries, power supply has to be increased also at a rapid pace. The previous chapter concludes that regional disparity in demand and supply of electricity in the four countries of the region could be bridged through enhanced power trading among these countries. The issues related to economics and transfer of energies and potential of power markets will be discussed in the later part of this chapter.

5.1 An Overview

An analysis of the economic, geographical and social situation of these four countries shows that energy demand and supply, plays a crucial role in the economic growth of these countries

Table 5.1: Peak Power Demand in SAGQ Subregion (in MW)

Year	Bangladesh	Bhutan	India(E&NE)	Nepal	Total
1992	1,950	19	8,198	216	10,383
2000	2,800	72	15,000	326	18,198
2010	5,000	120	20,000	800	25,920

Source: ADB, 2001.

Another major aspect of the energy scenario is that only Bangladesh, India and Nepal is having the private sector participation in generation of

electricity. At this time there is no private sector participation in any segment of the Bhutan power sector. India invites many private player in this sector in recent years. This may change the situation.

The transfer of energy in general and electricity in particular across countries in this region is justifiable because of mainly the economic conditions and the pattern of consumption and the mismatch of resources. A USAID/SARIE[1] report also proposed some options for energy phase trade in different steps.

This chapter reviews the existing power trading arrangements between the countries of the region. The bilateral nature of such arrangements have been built through the political process. In this chapter we also discuss the benefits of cross border power interconnections, the principles and condition for such trading. Some of the existing power pools across the world are also briefly discussed.

5.2 Existing Power Trading Arrangements

Due to the locational asymmetry only India shares border with the other three countries of the region and hence is able to suitably utilize its position to transfer electricity across its borders The existing power trading arrangements in the region are discussed below.

ADB has launched several Regional Technical Assistance (RETA) projects in South Asia to develop the power market(ADB, 2000a). An initiative of the Chambers of Commerce of Bangladesh, Bhutan, India and Nepal held in Calcutta, India on 28-29 November 2000. The Forum brought together public and private sector representatives as a step towards identifying an

[1] Nexant prepared a report for USAID-SARI/Energy, November, 2001

investment program to develop the region. The Forum recognized that public-private partnerships would be the main instrument of transformation, especially in undertaking infrastructure projects in the subregion (ADB, 2000b). ADB also set ups South Asia Subregional Economic cooperation (SASEC)[2]. This is subsequently discussed in this chapter.

Similar efforts are also been made from United States Agency for International Development (USAID) for establishing a regional power pool through South Asia Regional Initiative - Energy (SARI-E) programme.

5.2.1 India and Nepal

Bilateral cooperation exists between India and Nepal for the transfer of electricity. Nepal exported about 23 GWh electricity to the eastern region of India and imported 60 GWh electricity from the eastern and northern region of India in 2000 (India, 2002b).

Currently, there are 19 different interconnections for power exchange with India. These include three 132 kV, ten 33 kV, and six 11 kV connections with the Indian States of Bihar and Uttar Pradesh. The other connections are at 66 kV and 33 kV. Nepal does not currently transfer power to or from Bhutan or Bangladesh.

This is helping both countries avoid the construction of high cost transmission grids across mountainous areas. Nepal is also planning to develop large hydropower projects to meet its own demand and for export

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[2] SASES is a Subregional development Programme of Asian Development Bank. SASEC comprises Bangladesh, Bhutan, Eastern states of India and Nepal This program is aimed to develop economic activities in this South Asia Growth Quadrangle (SAGQ) region

of surplus power to India In January 1996, India signed an agreement[3] with Nepal for sharing the water of the Mahakali River. This two countries have agreed to commission a project of 1,200 MW hydro power plant on the Kosi River and are discussing a 6,000 MW project at Pancheshwar on the Mahakali River and a 600 MW project on the Budhi Gandhaki River.

5.2.2 India and Bhutan

Bilateral cooperation also exists between Bhutan and India for hydropower projects. About 75% of Bhutan's electricity generation is exported to India. During the 1992-2000 period, India has purchased power at an average rate of 1,400 GWh per year. During the 1999-2000 fiscal year, exports amounted to 1,626 GWh. Bhutan also imported a small amount of electricity, about 27 GWh, from India for its remote places where Bhutan national grid could not reach and for Indian Border towns.

The Chukha hydro scheme (336 MW) was financed, designed and executed by India for Bhutan under an agreement to purchase surplus electricity by Eastern Grid of India on a long term basis. This project had a major impact on the availability of energy in Bhutan and on the country's power export. India has been purchasing power from Bhutan's Chhukha power plant. Success of this project has led to the commencement of work for the 1,020 MW Tala (Chukha-II) hydroelectric project, planning of Chukha-III (900 MW) project and 1,525 MW Sunkoshi (Wangchu) project. The majority of the Tala HEP output (approximately 1,000 MW) will be exported to India under a bilateral agreement. Bhutan does not directly transfer power to or from Nepal or Bangladesh. For longer-term access to sustainable energy sources, Bangladesh could also profitably join India and Bhutan in developing hydropower projects in Bhutan.

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[3] "Treaty concerning the Integrated Development of the Mahakali River, including Sarada Barrage, Tanakpur Barrage and Pancheshwar Project", with GOI and HM govt of Nepal

5.2.3 India and Bangladesh

Currently, there is no power exchange between Bangladesh and any of the other Four Borders countries. Bangladesh is surrounded by the Eastern region of India on the Western side and by the Northeastern region of India on the Eastern side and is in close proximity to Nepal on the Northwest side. Two 220 kV direct current (DC) interconnections are under consideration, these are Krishnanagar/ Farakka-Ishurdi (Bangladesh) between the Eastern Region of India and the Western Region of Bangladesh; and Shahjibazar (Bangladesh)-Kumarghat (initially to be operated at 132 kV level) between the Northeastern Region of India and the East Zone of Bangladesh. These interconnections could transfer power in the amount of about 150 MW (India, 2002b).

The least cost, short-term option for Bangladesh is to import power from West Bengal (India) where surplus capacity presently exists. This will help Bangladesh avoid high investment costs for generation plants. India has installed generation capacity of 12,000 MW in the eastern region. Limited capacity transmission lines can be easily built to transfer power linking the grids in West Bengal and the eastern region of Bangladesh. Cooperation between India and Bangladesh can commence with transfer of electricity on a small scale initially 150 to 200 MW from the East Zone of India to West Zone of Bangladesh (Nexant, 2001). Simultaneously, Bangladesh may consider exporting about 50 to 100 MW of power to Tripura state in Northeast India from its eastern side. In Tripura, low electricity demand does not justify installation of an economic scale power station. Simultaneously, consideration could be given to develop about 3,000 MW of hydropower in Meghalaya and Arunachal Pradesh states of India to supply Bangladesh. Notwithstanding the potential for developing hydropower in the Northeast states of India, cooperation in small-scale power transfer

will benefit both Bangladesh and India. The feasibility of such a power exchange project is being supported by ADB under the India - Bangladesh Electricity Exchange Project (ADB, 2003).

India-Bangladesh Electricity Exchange Project, a small-scale technical assistance project approved in 1997. This supported the preparation of a feasibility study for bilateral cooperation between India and Bangladesh involving limited power exchange which could lead to the development and implementation of more capital intensive and complex generation-cum-transmission projects.

5.3 Potential Benefits of the Trading [@]

Major benefits of electricity trading are associated with the development of power interconnections and regional trading: improved security of supply, better economic efficiency, and environmental enhancement and protection. Historically the first two factors have been the driving force behind power interconnections and regional trading throughout the world There are another four possible reasons to support electricity trading among the countries in this South Asian region. These are briefly also discussed below in details.

5.3.1 Improved Security and Supply

As an isolated power system, the security and reliability of the electrical supply is directly related to the type, size and amount of installed generating capacity within that power system. Power interconnections built primarily to provide security and reliability of supply are characterized by

[@] This section heavily drawn upon Nexant, 2001, "The Four Border Project Reliability Improvement and Power Transfer in South Asia, Prepared for USAID-SARI/Energy Program, November

the low volume of electricity that is traded during normal conditions in comparison to the capacity of the interconnection. For certain fuels or resources, such as hydropower, lignite and renewable resources, power trading is the only feasible means of making these resources available to other areas. Power tradings facilitate the development of these diverse energy resources for the benefit of the entire region

5.3.2 Increased Economic Efficiency

Subsequent to the development of electricity trading to support increased system security and reliability, power trading have gained importance as a mechanism to improve the economic efficiency of power systems. With the development of power trading, individual power systems can be operated and expanded as part of a larger regional system. Meeting the combined electricity demand of regions with non-coincident peak demand both reduces the requirement for installed generating capacity for the overall power system and increases the utilization of mid-range and peak load generating facilities. Development of energy resources, such as hydropower which rely on power trading for delivery to major load centers, will enhance the business opportunities of the remote areas.

5.3.3 Enhanced Environmental Implications

In recent years the environmental aspects in the production and consumption of energy have received increased attention. Changes in the types of fuel used in electricity production affects overall air pollution and emissions in a significant manner. Fossil fuels used in the production of electricity emit pollutants. Substituting new and renewable energy sources, such as hydropower, solar energy, wind energy, tidal power or geothermal; or utilizing natural gas rather than coal or oil reduces a regions dependence on fossil fuels and the attendant air pollution and emissions.

market. This consideration is particularly important for countries in which generating resources are controlled by a company with monopoly power Power sector reform in small countries is more effective when a regional market is established for an unbundled power sector, because regional markets facilitate competition.

5.3.7 Macroeconomic Benefits

Generation cost savings enable suppliers to provide electricity at lower prices to the customer Reliability improvements either reduce the economic cost of power outages or bring cost savings that can be passed on to the consumer. Competitive markets provide the incentive to improve efficiency and provide the consumer with the best combination of price and quality. When electricity trade results in lower prices, the economic development of the region is promoted.

5.4 Principles of Cooperation

5.4.1 Sub Regional Cooperation

Asian Development Bank initiated the energy transfer ideas across the countries in the East Asian region. The experience of the Greater Mekong Subregion (GMS) in this regard is considered to be the best fit for Asian developing countries. The GMS experience will also be discussed in the later part of this chapter.

India has substituted indigenous energy source for oil. The most important indigenous source is coal, which supplies over one half of primary energy. Although coal is the most important source of energy in terms of share of final energy consumption as shown in section 3.4. The alternative is only the electricity. It is observed and analyzed that the hydropower in the neighboring countries like Bhutan and Nepal is an economically viable

option. Similarly, Bangladesh has 16.3 Trillion cubic feet of recoverable gas reserves and that is the only notable domestic source of primary energy. This trading will help to grow all the countries faster.

It has to be borne in mind that subregional cooperation is, at least in the first phase, essentially economic cooperation, not a political one. The process and implementation of this energy trading should encourage the government and private sector equally.

5.4.2 Implementation

There is a tendency for cooperating countries to treat cross-border projects as special projects which need more political rather than commercial decision making. The governments of the participating countries make policy decisions to cooperate in a particular sector. The governments concerned should provide the political umbrella by way of enabling agreements covering the sector as a whole. This agreements and memoranda of understanding are also sited by the Nexant proposal

5.4.3 Policies

Once it has been decided that a particular project like electricity transfer will be a candidate for subregional cooperation, the participating countries have to analyze their respective laws dealing with the subject. In this respect the Greater Mekong Subregion (GMS) experience may be referred easily. Initially, there may be some problems implementing and executing the projects, but policies must also be flexible enough to accommodate possible problems that may arise in the first few years of its implementation.

5.4.4 Social Acceptability

The worst that can happen to any large infrastructure project is for it to stall halfway through its implementation. Such delays are caused by inadequate planning on addressing social concerns related to the project, which are complicated by perceived concerns like environment problems, eviction etc. Another major implementation issue is that the costs are being borne by one country while the project benefits another.

5.4.5 Sharing of Benefits and Risks

It is obvious that no subregional project can be taken up if there is no benefit to each participating country. But the benefits may not be in the same areas. For example, a project to export hydroelectric power from Nepal to India, has different benefits to the two countries. To Nepal, it could mean expansion of its markets and sharing of developmental risks, which could make implementation of a large project possible. To India, it could mean an increase in its resource base, and a competitive source of power. A hydroelectric plant in Nepal may simply benefit India and Bangladesh through flood control and increased navigation, and thus be worthy of support.

5.5 Issues Related to Power Trading

Although power trading have the potential for providing economic and environmental benefits, several issues need to be addressed and resolved before proceeding with power interconnection development. Naturally the economic and technical viability of an interconnection project and associated power infrastructure expansion program initially should be studied and confirmed. However, to achieve a sustainable benefit from the development of a power interconnection project or the initiation of regional trading the institutional, regulatory and policy issues outlined below require consideration and resolution.

5.5.1 Technical Challenges

Technical issues facing the development of power interconnections and regional trading can be categorized as planning issues, operational issues and connection issues. Operational issues consist of, among other items, the definition and determination of system security standards; the issuance of dispatch instructions for the transmission grid and connected generating facilities, the communication protocols between control areas or regions, and the procedures employed during system emergencies.

5.5.2 Commercial Issues

Power interconnection projects are developed when they demonstrate a positive net economic value. As outlined above, there are three major objectives for developing a power interconnection project. When the primary objective for developing the power interconnection is to facilitate improved economic efficiency through regional trading, the economic value will be judged on the basis of the cost of energy and/or capacity being sold. This is not to suggest that Power Purchase Agreement (PPA)s are a barrier to regional trading or market reform. The key to success, from a regional trading perspective, is the level to which the various forms of risk management tools can be harmonized in a seamless fashion within the regional trading market. Electricity prices often have been used as the vehicle to promote Government social policies through subsidies to particular classes of customers, cross subsidies between classes of customers, non-sustainable tariff levels to the benefit of all customers, fuel subsidies to generating facilities, and non-commercial capital repayment conditions.

5.5.3 Governance and Legal Issues

To initiate any power interconnection proposal, the structure of project management, ownership and the relationship among investors, operators, dispatchers and regulatory entities is vitally important. Lack of appropriate rules on these matters, which take care of the mutual interests of the parties involved, or lack of transparency of such rules will affect the confidence of all potential developers of interconnection projects These rules often are referred to as governance. To resolve any disputes related to trading and other legal issues World Bank and United Nations have formulated International Center for Settlement of Investment Disputes and United Nations Commission on International Trade Law respectively. On the other hand, safeguards should be considered by the countries involved in regional trading to protect the public's interest. Appropriate licensing or certification processes will need to be developed if private parties are involved.

5.5.4 Financial Issues

Power interconnection projects that are proposed for countries where internal funds for infrastructure investment are limited will need to be able to attract an infusion of private capital. Alternatives, commercial loans or funds and private investment from international capital market should be jointly explored as well as possible support from international financing institutions like ADB, through soft loan arrangements and other favorable financing instruments.

5.5.5 National Policy and Supply Security Issues

Each region or country involved in the regional electricity trading will take on some portion of the financial burden of the proposal and thus will want assurance as to the economic benefit it will derive. Regional trading will impact the development of the domestic energy supply. Regional trading

needs to be identified and integrated into each countries economic and energy policies for the electricity sector. Power trading have been shown to enhance the security and reliability of a country's electricity supply through the access of support during times of emergencies.

5.6 Conditions of Trading

Nexant, (2001) has cited that it is useful to distinguish two possible conditions of electricity trade among interconnected power systems. Already we have discussed in section 5.2 the details of existing power transfer between India and Nepal and India and Bhutan with the existing power transmission line.

5.6.1. Import, export, and transit among a group of countries

This kind of trading arrangement enables the countries to maximize the benefits from electricity trade. In this situation it is possible for a country to import electricity from a country that is not a neighboring country. When a large geographic area is involved, the number of possible import and export transactions is very large; this is the most favorable condition for a competitive electricity market to develop. To facilitate energy flows over a large number of possible physical paths it is necessary to have one large synchronous interconnected system. A small number of physical paths can be implemented by asynchronous trading. In some regions both synchronous and asynchronous trading are needed to create a single market for electricity.

5.6.2 Export-import trade between neighboring countries

This kind of trading arrangement permits the countries to obtain only limited benefits from electricity trade. These transactions can be implemented with either AC or DC interconnections. Asynchronous (DC) interconnections are used where it would be very difficult to achieve a high

degree of coordination or to implement uniform standards for network construction and operation. When a country imports electricity from its neighbor, in some cases the electronic energy flows over a short physical path (for example, 100 km). Perhaps the simplest example of import-export trade between neighbor countries is the connection of a small "island" to a large neighbor country.[4]

5.7 Generating Cost Differences of Trading

To develop interconnections that will support competitive electricity markets, or to develop competitive markets that will support interconnections, it is necessary to understand the economic forces supporting electricity trade among countries. From a legal standpoint it may be possible to create a "single electricity market" over a large region such as the European Union (EU) but transactions between producers (or suppliers) and end users will not cross national boundaries unless there is an economic rationale for cross-border trade. In this respect it is useful to compare the cost of power generation and transmission in different countries, and estimate the cost of interconnections, regardless of the ownership of the assets and the identities of buyers and sellers. There are many conditions that are associated with the electricity trading. These are discussed in this chapter consequently.

5.7.1 Existing Generating Capacity

At least one country in the region has existing generating capacity that can produce electric energy for export at relatively low cost. Common examples of exporting countries are those with vast, low-cost hydroelectric resources; those with large hydroelectric generating capacity

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[4] For example, Uralsk and Aktyubinsk are located in Kazakhstan but connected to the Russian power system because they are far from the main interconnected power network of Kazakhstan In 1999 the unified power system of Russia operated in an island mode with the power systems of Kazakhstan, Finland, Norway, China, and Mongolia For more details see the link http //www.cdo org

but very limited reservoir capacity, who need to export surplus run-of-river hydro when the reservoirs are full; and those with large nuclear generating capacity who need to export nuclear generation during off-peak periods. Here we may refer to Bhutan and Nepal as an example with having hydroelectricity and India as the example for nuclear generation.

5.7.2 New Generating capacity

At least one country in the region can build new generating capacity that can produce low-cost electric energy for export. A common example is a region in which a few countries have large undeveloped hydroelectric resources while the other countries have very limited opportunities for further development of their hydroelectric resources. Another example is a region in which one country, for example Bangladesh has very large natural gas resources but limited opportunities to export gas; this country may be able to export gas-fired electricity generation.

5.7.3 Mix Generation

During many hours of the year, the countries in the region have different levels of short-run marginal cost of electricity generation. For example there could be a region in which base load capacity is concentrated in one country, peaking capacity is in another country, and intermediate capacity is in a third country. Together these three countries may have a reasonable mix of generating resources available to meet the load duration curve of the region as a whole, but each country individually has the "wrong" mix of generating resources.

5.7.4 Isolated Power Generation

A significant portion of each country's electricity consumption is located in urban areas or large industrial plants that are most efficiently served by electricity networks. The opportunities for isolated power generation

(diesel generators and small-scale renewable resource generation) are limited to rural areas and remote locations that do not represent a large share of national electricity demand. The first two conditions can be the driving force behind construction of new interconnections. The third condition – the diversity of incremental generation costs – may or may not be sufficient to justify investment in an interconnection. The fourth condition is necessary but not sufficient to justify investments in interconnections.

5.8 System Reliability Factors Affecting the Need for Interconnections

In this paragraph we will discuss some issues related to the system reliability and need for interconnections.

5.8.1 Sharing Responsibility

In small isolated electricity networks it is difficult to cope with generation system failures (unscheduled outages at generating units) or transmission system failures (usually, damage to transmission lines caused by storms or accidents) and therefore it is difficult to maintain a high level of reliability. The solution is to connect to a larger network that already exists, or to form a large network through interconnection of many smaller networks. These interconnections reduce the cost of generating capacity reserves, including spinning reserve (or hot reserve) as well as installed generating capacity (or cold reserve). When a small system joins a large system, the smaller system is almost always the one that benefits. In some instances the addition of the smaller system is justified on the basis of political cooperation or is considered a form of economic development assistance provided by the countries in the larger interconnected system. Otherwise, the smaller system could be asked to pay a major share of the interconnection costs because it will receive a major share of the benefits.

5.8.2 System Reliability

An interconnection between two countries may reduce the cost to both countries of achieving a target level of generation and transmission system reliability. The stability of a transmission system depends not only on its size, but on the number of multiple paths over which electricity can flow from generating units to end users under a variety of accident (system fault) scenarios. A ring-based network is always more stable, for example, than a radial network, because a break at any point along the ring will not prevent electricity from flowing in the remaining portion of the ring. The ability of electric energy to flow over alternative paths from generating stations to major load centers (cities or large industrial consumers) depends on the location of the generators, the location of the loads, and the capacity of the transmission lines. A very large generating station, or a very large city, must be connected to the grid by two or more high-voltage transmission lines.12

5.8.3 Stable Voltage Level and Load

In any interconnected system it is desirable to maintain a stable level of frequency and voltage in the transmission system (roughly speaking, voltages of 110 kV and higher) by constantly maintaining a balance between total power generation in MW and total load in MW. This is easier to accomplish when a country has access to hydroelectric stations or thermal power stations that can rapidly adjust power output in response to dispatch instructions. Interconnections may provide access to such generating resources over a large geographic area.

5.8.4 Maintaining constant Voltage and Frequency

If a large country or a large power system cannot maintain stable frequency and voltage, none of its neighbors will want to be interconnected with it. For example, Ukraine has difficulty maintaining stable frequency

and voltage in its high-voltage network, and therefore Poland and Hungary have disconnected their power grids from Ukraine despite the fact that the high voltage networks were designed to support east-west power flows. If a large country normally maintains frequency and voltage within an acceptable range but is unable to provide a reasonable guarantee of stability, neighbor countries will reserve the right to disconnect instantly, using automatic control equipment. For example, the agreement among the power systems of Russian and the three Baltic countries (Estonia, Latvia, and Lithuania) allows the Baltics to disconnect from Russia in an emergency when frequency falls suddenly in Russia or becomes very unstable.

5.9 World Experience

Over the last 50 years, there has been a global trend in which power systems have formed regional electricity associations to link countries together. Here in this chapter we will discuss some Asian and World experience with reference to the electricity grid network and subregional growth.

5.9.1 GMS Interconnection Project

5.9.1.1 A brief History

The Greater Mekong Subregion (GMS) is made up of the six economies that border the Mekong River, namely Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam, and Yunnan Province of China. The origins of the GMS interconnection project can be traced back to a 1968 agreement between Lao PDR and Thailand on the exchange of electric power. However, the GMS interconnection project as now contemplated is only of relatively

recent origin. It arose from GMS member economies deliberating during the 1990s on the coordination of their electricity infrastructure investment and considering other means of social and economic collaboration which could strengthen their competitive position and growth prospects.

5.9.1.2. Overview of the GMS Power Sector

The contrast in economic development between the three non-APEC and the three APEC economies in the GMS is dramatically presented in the table below. As can be seen, the electrification ratio varies widely, ranging from only 13% of households in Cambodia to over 90% in Yunnan Province.

Table 5.2: GMS ECONOMIES — SELECTED POWER SECTOR INDICATORS (1999)

Indicator	Units	Cambodia	Lao PDR	Myanmar	Thailand	VietNam	Yunnan (PRC)
Population	Million	11.6	5.1	48.1	61.3	76.3	41 9
GDP	UD$ billion	3.1	1.4	NA	123.9	28.6	NA
Electricity Use	kWh/cap/yr	34	113	60	1300	257	606
Installed	MW	150	635	1300	22300	6200	7600
Peak Demand#	MW	114	167	780	14918	4890	5257
Sales#	GWh	381	649	3366	86214	22241	27696

Year 2000 Data

Source : GSM, 2001.

There are abundant energy resources in the subregion but they are unevenly distributed. Each economy's power system is isolated from each of the others except for Thailand and Lao PDR which are interconnected, albeit inadequately, and some islanded interconnections with distribution level loads. In Cambodia, the industry comprises 22 small isolated power systems without any transmission grid. In Lao PDR, there are three separate regional grids. Thailand is clearly the dominant power market in the GMS, representing around 60% of total demand, although this is expected to decline over time with demand growth in other GMS economies. Electricity consumption in the GMS has in recent years past been typified by rapid growth, driven by economic growth, industrialization,

urbanization and globalization of trade. During the first half of the 1990s, increases in electricity sales reached doubled digit rates in most of the GMS economies. Due to the "Asian financial crisis", from 1996-97, there was a marked reduction in growth rates in most of the GMS economies although only Thailand experienced reduced electricity consumption (in 1998 and 1999)[5]. By 2000, electricity sales in Thailand exceeded pre-crisis levels. In all the GMS economies, growth rates in 2000 exceeded those in 1999.

The hydropower potential of the GMS is very large, some 1000 TWh annually. If it is assumed that 50% of this hydropower potential is economically and environmentally feasible, this represents a potential generating capacity of about five times the present total generating capacity in the subregion[6].

5.9.1.3 The 1990s Momentum for Interconnection

In 1990, Thailand appointed a Thailand-Myanmar Border Hydroelectric Project Committee to be responsible with the Myanmar Government for coordinating the development of hydroelectric projects In 1997, Thailand signed an MOU with Myanmar to supply power to Thailand by 2010 and, in 1998, a series of hydroelectric projects were considered with this in mind. In 1993 and 1996, Thailand signed MOUs with Lao PDR to import power up to an eventual capacity of 3000 MW. In 1993, the Yunnan Electric Power Group of China and the Electricity Generating Authority of Thailand (EGAT) began to discuss the development of hydroelectric projects in Yunnan and the sale of electricity to EGAT. In 1998, China and Thailand signed an MOU on a power purchase program between China and Thailand. In 1998, Lao PDR and Viet Nam signed an MOU for the supply of

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[5] Reference · Crousillat, E, 1998

[6] Reference . Chonglertvanichkul, P, 1999

power from hydropower plants in Lao PDR to Viet Nam. In 1999, Viet Nam and Cambodia signed an agreement for the supply of power from Viet Nam to Cambodia, supplemented in 2000 by a power trade agreement between the Energy Ministries of each economy. A number of other MOUs and agreements have been signed in the subregion in recent years.

5.9.1.4 The GMS Program of Economic Cooperation

In 1992, following the onset of peace in the subregion, and with the assistance of the Asian Development Bank (ADB), the GMS economies launched a program of economic cooperation, designed to enhance economic relations among its members. Broadly identified as "the GMS Program", the program has contributed to the development of infrastructure to enable the development and sharing of the resource base, and promote the free flow of goods and people within the subregion. The GMS Program has also led to the international recognition of the subregion as a growth area. Under the GMS Program, the ADB has identified eight priority sectors for involvement including transport, telecommunications, trade, investment, environment, human resources development, tourism and energy. As at October 2000, the ADB had committed a total of US$800 million to the GMS Program, either in loans or technical assistance grants. The ADB has played a crucial role in the evolution of the GMS interconnection project. It has financed feasibility studies, it has provided valuable technical assistance and it has directly financed parts of the work. In addition, it has mobilized resources from other multilateral and bilateral agencies and from the private sector. In 1993, the ADB commissioned a Norwegian consulting company, Norconsult International, to undertake an energy sector study for the GMS. The aim of the study was to identify the scope, opportunities and means for enhancing cooperation in the field of water resources, electric power

and natural gas within the subregion. In 1994, the Norconsult study recommended hydropower as the most environmentally benign solution to

the projected demand for energy in the subregion and also recommended the development of a subregional grid system to integrate regional supply and demand. The study and its recommendations were endorsed by the GMS governments. The opportunity for power trade in the subregion has been described as arising from "the mismatch of supply and demand among countries in close proximity" [7]. The World Bank has provided valuable advice and technical assistance to the GMS interconnection project and has carried out a major study on power trade strategy for the subregion[8]. This assistance has mainly been provided through a special global technical assistance program known as the Energy Sector Management Assistance Program (ESMAP). This is sponsored by the World Bank and the UN Development Program (UNDP) and relies on donor funding for its activities. ESMAP is managed by the World Bank.

5.9.1.5 GMS Electric Power Forum (EPF) and GMS Experts Group (EGP)

In 1994, the six GMS economies established the GMS Electric Power Forum (EPF) as a subregional forum. Its purpose was to facilitate dialogue among ministerial and operating units within the GMS and to provide advice and recommendations to ministerial-level meetings. In 1998, the EPF in turn established an Experts Group on Power Interconnection and Trade (EGP). The purpose of the EGP was to assist the GMS economies to promote the development of a regional transmission network and to facilitate the expansion of cross-border power trade. In particular, the EGP was expected to undertake, with bilateral and multilateral technical assistance, studies to develop strategies and basic rules on transmission links. At the second meeting of the EGP, a work program for the EGP was adopted which included a draft policy statement on regional power trade, a regional protocol, a master plan and design criteria for generation and transmission.

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[7] Reference . Crousillat, E, 1998

[8] World bank, 1999.

5.9.1.5 Recent Benefits

During the time, from 1995 to 1999, significant developments have carried in the regional power situation. Cooperation among the members have steadily increased resulting in the development of a number of subregional power projects such as Theun Hinboun and Houay Ho in the Lao PDR, which are exporting power to Thailand. Another project of regional importance, the Nam Leuk Hydropower Project, also in the Lao PDR, has been commissioned in April 2000 and is now exporting its output to Thailand.

5.9.2 Nordic Area@

Countries in Scandinavia have a long tradition of electricity sector cooperation and the Nordic area is now operating a unified market through a single power exchange. Since 1996 the Swedish and the Norwegian grid companies have owned and operated a common power exchange, Nord Pool. The exchange now includes participation by actors from Finland and Denmark.

5.9.2.1 The Nordic Power exchange

Since 1971 the market for so called peak power has been acting as a clearinghouse for inter-utility trade in Norway. The need for such a market stems from the fact that the Norwegian electricity system is nearly 100% hydropower based, with production varying extensively with hydrological conditions over the country, years and seasons. This means that hydro-

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1 @ This section heavily drawn upon **NER, 2000**, "International Experience with Regional Regulation", National Electricity Regulator (NER) of South Africa", March

producers have needed a system to exchange power to deal with the variation and uncertainty in hydrological conditions.

This peak power market later developed into Nordic power exchange, Nord Pool, and established the basis for one of the first competitive power markets. With power sector reforms in other Nordic countries, the market has extended to include Sweden, Finland and west Denmark. In the Nordic wholesale market, the Nordic power pool is an essential component, providing a framework for competition whilst performing the essential functions of dispatch and the balancing of supply and demand. The power exchange is owned 50/50 by the state owned Norwegian grid company Statnett and the state-owned Swedish power grid company Sventska Kraftnat. Statnet and Svenska Kraftnat are also the TSOs in Norway and Sweden respectively.

5.9.2.2System of points tariffs

The network tariffs in the Nordic area are strict point-tariffs, which are fixed and published. With some special exceptions, this is also true for cross-border transactions between Norway, Sweden and Finland: there is no cross-border change in addition to the local network access charges with respect to power traded through Nord Pool. However, some bilateral cross-border tariffs(Denmark for example pays an extra border tariff for the Swedish Kontiskan cable). It is planned that these tariffs should be phased out in the next few years to make the point tariff system consistent.

5.9.2.3 Different principles for cost allocation

The proportion of transmission costs allocated to generation and consumption differ considerably in the Nordic transmission system, especially since Finland has moved to an almost complete cost allocation towards consumption. In general, it is considered sensible that these ratios should converge. However, given other distortions such as different tax regimes, it is not considered essential that this convergence be treated as a high priority.

5.9.2.4 The role of regulators

The Nordic electricity market has tradiotionally been highly regulated. The degree to which the Scandinavian countries are liberalized varies - and therefore also the extent of regulation. For example Denmark is the only country that currently does not have full retail competition for all end users. In Norway and Denmark the liberalization has not, to date, included much privatization of general assets or private investment in new general capacity. In Sweden and Finland there is a more liberal policy towards private and foreign acquisition and ownership. The development of regulatory techniques (benchmarking schemes, revenue cap regulation etc.) for network activities has progressed more in Norway than in the Nordic countries. Each Nordic country has a special regulatory agency for the Electricity agency.

5.9.2.5 Regional co-ordination between regulators

There exists no overall official Nordic regulatory authority that co-ordinates regulation activities and handle disputes. The official co-ordination activity takes place at the European Union(EU) level. There are

however bilateral and unofficial meetings between the Nordic countries where different regulatory issues are discussed, for example, within the Nordic Council of Ministers.

Disputes concerning, for example, cross border trading/pricing among the countries are traditionally solved. There are very few cases where the energy regulatory authorities have together been involved in disputes between actors in different countries.

5.9.2.6 Comments on Nord Pool

The Nordic area represents a case where there is a high level of integration between countries, and where the market mechanisms are fairly mature and established. While the market incorporates a high degree of international trade, it has not been necessary to advise one set of transmission pricing rules for the entire region. Nevertheless the point-based system for network charges has proved to be suitable in dealing with most trade issues. The system works even though each country has a different method for defining the point charges. The co-opreration between the regulatory bodies in the Nordic area takes place at more or less informal meetings. The official co-ordination activity mostly takes place at the EU level.

5.9.3 The Russia-China Interconnection Project

The general context of the Russia-China interconnection project has been outlined above. Some limited power exchanges between China and Russia are already being realized at the border. The two economies have one of the longest land borders in the world (4300 km) and it seems only logical that further cross border interconnections should be pursued for mutual gain.

In 1995, China and Russia commenced discussions which would involve Russia transmitting hydroelectricity from Siberia to Northern China. The governments of both economies have also engaged in discussion under the framework of the Energy Sub-Commission of Regular Premiers Meeting Commission. In 1997, a joint Russian-Chinese working group conducted a pre-feasibility study for the "Russia-China Power Export Project" assisted by experts from PTI of the USA, ABB of Canada, ABB of Sweden and Manitoba Hydro of Canada. A Russian-Chinese Sub-Commission for Cooperation in the Energy Sector has been established. Working groups on oil and gas and electricity have been set up as part of its brief. In July 2001, China and Russia signed a Treaty for Good Neighborliness, Friendship and Cooperation, the first such agreement between them for 50 years. This very significant treaty singles out energy and raw materials supply as one of five important areas of cooperation.

One possible element of the project envisages Russia exporting a power surplus of up to 18TWh per year from the Irkutsk power system into the Beijing region in China. The line capacity using 600 kV HVDC lines would be 2-3 GW with an annual volume of 10-15 TWh. The shortest route would be 2500 km through Mongolia and would cost an estimated US$1.5 billion. An alternative route avoiding Mongolian territory would add another 1500 km to the line. In 1999, the Chinese government indicated that the project may not be viable for at least five years due to power over-supply in the north and north-eastern parts of China. The project could be reactivated if a power shortage develops in future in these regions of China. A second possible interconnection could in future link the Amur region of Far East Russia with Kharbin in the northeastern region of China. This would involve a much shorter transmission line of 700 km using a 400 kV HVAC line costing US$250 million. However, it would also require completion of

the unfinished Bureyskaya hydropower plant at an estimated cost of US$2 billion. Neither of these projects appear economically viable until the demand for power in northern China increases appreciably. There are no project-specific efforts being made to proceed until economic feasibility is indicated. In the meantime, regional dialogue on economic cooperation is accelerating as we have earlier described.

Chapter 6
Conclusions

This thesis forecasted the demand of electricity compare it with the supply scenario in 2006-07 for the four countries in the SAGQ region. In a medium growth scenario, total electricity demand in this region in the year 2006-07 is projected to be 836159.82 GWh with a required capacity of 163944.94 MW The existing capacity by 2006-07 will be 150163.27 MW with all the expected capacity addition. This represents a shortfall of 69091.42 GWh of capacity 13781.67 MW. India has the highest shortage in this region of 71508 02 MW capacity being expected to add more capacity to bridge the demand or trade with the neighboring countries. In the high growth scenario, the region is expected to face an energy shortage of 190659.63 GWh with the additional capacity of 37606.11 MW by the year 2006-07. Electricity demand is growing at a rapid rate and supplying that need will be a key to the expansion of the economies of the region. Co-locating plants can also be a demanding candidate to minimize the T&D losses of electricity to serve the remote part of the country and offer a win-win situation for the participating countries. Electrical power interconnections and regional trading have potential to offer significant benefits to the South Asia region in the future. However, higher trade potential exists due to seasonal variation of electricity demand as well as different hourly demand during a day.

However, we note that in order to develop this electricity market for the required power demand a number of steps needs to be taken. These include the common agenda, regulatory issues, tariffs of electricity and commercial and technical issues. All the participating countries in the SAGQ region must find benefit in the development of energy sources for security of supply and environmental benefits. For any power trading proposal to materialize, major technical, non technical and financial issues and concerns must be addressed by the involved government and the other effected stakeholders. Regional cooperation and the recognition of a certain level of mutual dependence with

regards to development and deployment of energy resources will be necessary. Political will and support will become increasingly important as the parties work through the issues outlined above.

The present study also has its limitations. Some of these are highlighted here. In this analysis we have not considered the substitution of energy resources and its effect on the electricity demand. A number of consumers in the region are not connected with the grid. Those who are connected also face power cuts; this represents a dormant demand that could not be considered in this study. The model also demands to take into account electricity sector reforms in the region which is expected to alter the tariff structure for various consumer categories.

Future research efforts could be made to analyze the requirement of electricity demand with more details and addressing some of the limitations identified above. A regional model for capacity expansion can also be developed taking into account the regional resources availability, demand pattern, investment climate and the electricity tariffs across the region.

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